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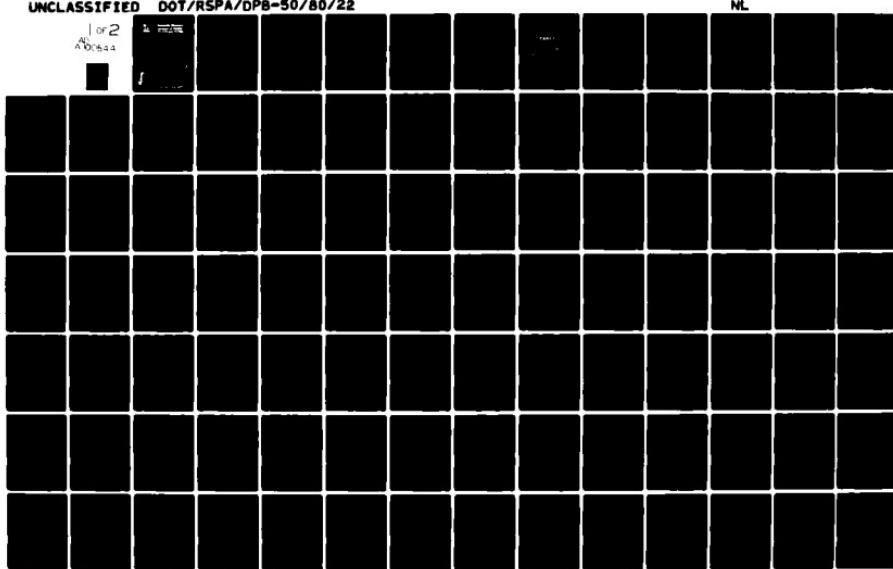
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION WASHING--ETC F/6 5/1  
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**SUMMARY OF AWARDS:  
FY 1979 AND 1980  
PROGRAM OF UNIVERSITY RESEARCH,**

14) DOT/RSPA/DPB-5//1

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Office of University Research

15) 469

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December, 1980

**U.S. DEPARTMENT OF TRANSPORTATION  
Research and Special Programs Administration  
Transportation Programs Bureau**

**Office of University Research  
Washington, D.C. 20590**

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## FOREWORD

This booklet contains the new awards and active contracts of the Program of University Research in Fiscal Year 1980. The purpose of the booklet is to disseminate research information to interested parties and potential users. The booklet is divided into three parts:

- PART I—FY 1979 and 1980 Research Summaries,
- PART II—FY 1980 Categorical Breakdowns,
- PART III—Listing of All Contracts in FY 1973 - FY 1980 \*

Part I, entitled "FY 1980 Research Summaries" is intended to assist in the exchange of information between researchers and practitioners, to provide state-of-the-art summaries for potential researchers, and to provide contract applications and status reports for all interested parties. This section contains detailed references and summaries of contracts funded during FY 1980 and previously funded contracts that were completed during FY 1980. The following sections are included in the summaries with the exception that contracts signed during the past three months contain only "General Information" and "Abstracts."

- *General Information*—This section is comprised of four parts: amount of money awarded for the contract, tenure of the contract, and the names and addresses of the principal investigator and contract monitor. These individuals can supply more detailed information about the research.
- *Abstract*—A summary of the initial objectives of the research, as well as an outline of the methods to be used. In the case of continuations or completed projects, the "Abstract" section may contain background on the work of the previous year(s).
- *Status*—Statement of the progress of the research in meeting its goal. Often this section contains more explicit information on techniques or methods. In the case of contracts that have been completed, or are ending, generalized research results may be listed under the heading of "Summary" or "Status."
- *Applications*—Where possible, actual application and implementation of the technique, methodology or product

are reported. In instances where the research has not fully matured, potential applications are listed.

Part II, entitled "FY 1980 Categorical Breakdowns," contains analytical information on the contracts listed under Part I. Projects are listed on separate charts by contract number, state, FY 1980 expenditures and subject area. A listing of minority schools participating in the program during FY 1980 is included. Also, a "Browsing Directory" is contained in this section.

Part III, entitled "Listing of All Contracts in FY 1973 - FY 1980," contains information on the Program of University Research during its eight years of existence. General information on contract funding, Program budget, titles of research projects, and location of contracts may be found in this section.

The Program of University Research is designed to assure that resources of the higher education community are effectively brought to bear on transportation problems. The program also encourages greater involvement of colleges and universities with the Department, State and local governments and the transportation industry. Since the inception of the Program in October 1972, the Office of University Research has sponsored 291 contracts in diverse areas of transportation research. The Program has expended 28 million dollars over an eight year period. Research results have been generated which are being applied in planning agencies, in private industry, and in the Department. A number of research reports have become standard references in their field. A companion document entitled "Transportation Research Results: FY 1973-FY 1980" is available from the Office of University Research.

The Program of University Research has matured and is proving successful in stimulating relevant, high quality and innovative transportation research at universities. We hope for continued financial support of the program and expanded involvement of the university community in dealing with transportation issues and in providing solutions to the Nation's transportation problems.

Sherwood C. Chu  
Director  
Office of University Research

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# **PART I**

**FY 1979 and 1980**

**Research Summaries**

## TRANSPORTATION SYSTEM DEVELOPMENT FOR ALASKA

### PRINCIPAL INVESTIGATOR

Lee Gorsuch  
Institute of Social, Economic & Government Research  
University of Alaska  
Fairbanks, Alaska 99701

### AMOUNT

1974 - \$74,500  
(\$10,041 in university funds)  
1975 - \$152,959  
(\$12,041 in university funds)  
1978 - \$55,000  
(\$20,000 in university funds)  
1980 - \$1,400

### TENURE OF CONTRACT

June 1973 - February 1980

### MONITOR

Carl N. Swerdluff, P-12  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4164

### ABSTRACT

A multi-modal, statewide transportation planning methodology is being developed in conjunction with Alaska University's "Man in the Artic" Program. The specific objectives of the research are:

1. To create a multi-modal transportation model for Alaska intra and interstate transport.
2. To relate the developed model to the "Man in the Artic" program's statewide and regional economic models.
3. To utilize the transport model package in an analysis framework to determine the impacts of different transport alternatives and policies upon the state economy.
4. To utilize the model package to investigate the role of oil development (and revenues) upon the state's transportation system.
5. To identify the effect of alternative technologies on demand and level of service.
6. To provide technical assistance to federal and state planning agencies.

### STATUS

Prior to the initiation of the study, little comprehensive data was available on the flow of passengers and goods entering, leaving, and moving within Alaska. The task of data collection was completed in January 1976 with the creation of the follow-

ing modal files: highway, marine (ocean, river, Alaska Marine Highway System), rail, rail barge, and air. With the completion of this phase, the calibration of conventional transport models began.

In the Fall of 1975, the Man in the Artic program completed its statewide economic model; regional models were finished in 1976, and made compatible with the transport evaluation techniques following necessary modifications to permit their integration. A second phase report, published in June 1977, summarized work completed on the development and calibration of the transport model, network stimulator, and integration of the transport models with the state macroeconomic models. Final calibrations, model split refinements, documentation and selected policy applications were completed in the third and final phase of the project. The commodity data base and network model were updated to 1977 conditions. The complete transport/economic model was then used to project and evaluate the various impacts of the alternative economic development scenarios and transportation investments on the state's transportation system.

### APPLICATIONS

The data base compiled by the research staff has seen considerable usage. Agencies utilizing the transport inventory include the Alaska Department of Highways, Alaska Transportation Commission, the Alaska Department of Public Works, the Governor's Office, The Alaska Railroad, Crowley Maritime Corp., Totem Ocean Trailex Express, the Ports of Anchorage, Valdez, Seattle and Ketchikan, Army Corps of Engineers, and Alaska Outer Continental Shelf Office. An analysis of transportation issues and problems was prepared for the joint Federal-State Land Use Planning Commission for Alaska. The air census has been used by the FAA to design a navigation system for Alaska's bush areas and also by Alaskan air carriers in petitioning the CAB for regulatory changes. In addition, a Federal Railroad Administration study used the research demand forecasting models to predict Alaska Railroad freight flows by commodity type. Rail data was also used by the Canadian government in studying the feasibility of a Canadian railroad system extension to Alaska. A preliminary application of the Model was also used to examine the feasibility of a transcontinental rail link and to assess the impacts of such a link on Alaska's transportation network.

In cooperation with the Alaska Department of Transportation and Public Facilities, alternative sets of long-term transportation forecasts are being projected. The Alaska DOT is in the process of adopting the research as a methodological basis for a state transportation plan and for a statewide and regional analysis of the implications of transport policy decisions. The research is also being used as a tool to assist in strategic port development planning. Finally, the Alaska DOT is providing funding for continuation and application of the project.

## UTILIZATION OF ICC OPERATING RIGHTS PRICES TO EVALUATE THE IMPACT OF ICC REGULATION

### PRINCIPAL INVESTIGATOR

Michael W. Putsay  
Department of Economics  
Bowling Green State University  
Bowling Green, Ohio 43403

### AMOUNT

1978 - \$52,622  
(\$2,947 in university funds)  
1980 - \$4,766

### TENURE OF CONTRACT

September 1978 - September 1980

### MONITOR

Karen L. Borlaug, P-54  
Lawrence Phillips, P-54  
U.S. Department of Transportation  
400 Seventh St., S.W.  
Washington, D.C. 20590  
(202) 426-4420

### ABSTRACT

The effect of ICC regulations on resource allocation in the motor carrier industry has been the subject of much contention. Opponents of ICC regulation have charged that the ICC has caused common carrier trucking prices to rise above their free market levels, allowed regulated truckers to earn excessive profits, restricted entry into the common carrier industry, increased the level of concentration in trucking markets, induced inefficient resource use within the industry, and misallocated traffic among the various transportation modes. These assertions have been vigorously denied by the ICC and the regulated carriers.

ICC motor carrier operating rights can be sold by their owners to other carriers subject to ICC permission. Economic theory suggests that the price paid for an operating right should reflect the expected present discounted value of the economic profits earned through possession of the right. This research uses this relationship to examine the validity of the above listed charges made by opponents of the current regulatory structure.

Data has been collected from publicly-available ICC records regarding the market value of ICC motor carrier operating rights. Using these data, standard econometric techniques were applied to assess the determinants of the market value of ICC operating rights. This assessment was then used to evaluate the effects of ICC regulation on trucking prices, rates of return earned by the carriers, entry into trucking markets, concentration in the industry, carrier operating efficiency, and the allocation of traffic among transportation modes.

### STATUS

Data on the market value and market characteristics of ICC motor carrier certificates have been collected and assembled according to tightly defined certificate markets. Following data analysis, a theoretical model of the determinants of the market value of ICC motor carrier operating rights is being developed.

### APPLICATIONS

The results of this research are being used by policymakers in DOT to gain insights into the future course of regulation of the Nation's transportation. PUC officials are utilizing this research in their analysis of regulatory decisions. Other potential users include the Office of Regulatory Analysis in DOT and the Bureau of Economics in the Federal Trade Commission.

## INTRASTATE MOTOR CARRIAGE AND FEDERAL POLICY TOWARDS SMALL COMMUNITY SERVICE

### PRINCIPAL INVESTIGATOR

Michael W. Pustay  
Department of Economics  
Bowling Green State University  
Bowling Green, Ohio 43404

### AMOUNT

1980 - \$63,500  
(\$1,400 in university funds)

### TENURE OF CONTRACT

September 1980 - November 1981

### MONITOR

Karen L. Borlaug, P-54  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4420

### ABSTRACT

An important concern in the debate over relaxing Interstate Commerce Commission (ICC) regulation of the interstate trucking industry has been the impact of regulatory reform on the services offered to small, isolated communities. While data exist regarding the quality, price, and extent of the interstate service to such communities, little information is available about the effect of intrastate motor carriage on the services supplied to small towns. Existing studies of ICC-regulated carriers generally do not consider alternative sources of motor carriage and also fail to account for the important interdependencies between intrastate and interstate motor carriage which may have an effect on any Federal regulatory policy changes.

This study examines the impact of intrastate motor carriage on the service offered to small, isolated communities. The study analyzes questions regarding the availability of intrastate service, the prices charged by intrastate carriers, and the competitiveness of intrastate small community markets. Linkages between intrastate and interstate services will also be examined. The impact of these linkages on the efficacy of Federal regulatory policy towards service to small communities will be thoroughly explored.

## MULTIMODAL TRAFFIC EQUILIBRIUM NETWORK MODELS AND ALGORITHMS

**PRINCIPAL INVESTIGATOR**

Stella Dafermos  
Division of Applied Mathematics and Engineering  
Brown University  
Providence, Rhode Island 02912

**AMOUNT**

1980 - \$48,000  
(\$4,528 in university funds)

**TENURE OF CONTRACT**

September 1980 - August 1981

**MONITOR**

Robert B. Dial, UPM-20  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9271

**ABSTRACT**

One of the main problems in transportation planning is to determine how the potential users of the transportation network select their means of transportation among a) the various modes (automobiles, rail, air, etc.) and b) the different routes that are available within each specified mode. Their criterion for mode-route selection is optimization of their "utility"; typical factors of which are out of pocket cost, travel time, comfort, convenience, safety, etc. The transportation planner's role is to predict the developing travel patterns and to examine how various policies can be implemented to achieve a) minimization of the overall social cost and b) promotion of the wellbeing of the individual users. This study will a) develop models which recognize that distinct individual users may have a different perception of the various components of utility and b) construct efficient algorithms (computational schemes) for the utilization of these models in predicting travel patterns and in minimizing travel costs through transportation policy planning.

**BROWN UNIVERSITY**

**CONTRACT NO: DT-RS-58-80C-00008**

## **COMMUNITY DEVELOPMENT AND CHANGING TRAVEL PATTERNS**

### **PRINCIPAL INVESTIGATOR**

Basil G. Zimmer  
Department of Urban Studies & Sociology  
Brown University  
Providence, Rhode Island 02912

### **AMOUNT**

1980 - \$52,291  
(\$15,663 in university funds)

### **TENURE OF CONTRACT**

July 1980 - June 1981

### **MONITOR**

Bruce Spear, DTS-243  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2276

### **ABSTRACT**

The objective of the research is to investigate the impact of urban growth and changes in urban structure on daily travel patterns among continuous residents of a single metropolitan area. The study utilizes a unique data set based on surveys administered twelve years apart to a panel of over 2000 households. The analysis examines changes in travel times and distances for work and shopping trips, relating these to residential and employment relocations and to socio-demographic characteristics and changes in the households themselves.

### **APPLICATIONS**

Results of this research are expected to provide greater insight into the relationships between travel behavior and metropolitan development by overcoming existing constraints caused by the lack of appropriate detailed, longitudinal data.

## ECONOMIC STRUCTURE, COMMUNITY DEVELOPMENT, AND TRANSPORTATION SYSTEMS: AN EMPIRICAL ANALYSIS OF HOUSEHOLD ACTIVITY PATTERNS

### PRINCIPAL INVESTIGATOR

Wilfred Recker  
Institute for Transportation Studies  
University of California at Irvine  
Irvine, California 92717

### AMOUNT

1979 - \$64,400  
(\$23,153 in university funds)

### TENURE OF CONTRACT

July 1979 - July 1980

### MONITOR

Jesse Jacobson, DTS-243  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, Massachusetts 02142  
(617) 494-2510

### ABSTRACT

This study is designed to empirically evaluate household activity patterns in order to assess the impacts of transportation systems and services available on both economic structure and community development in a multi-county region. The theory of travel behavior implicit in this approach relates household activity patterns (i.e., a collection of activities) directly to site locations and specific economic activities in the environment. The rationale for this approach is that by knowing how people respond to travel choice situations (i.e., how individuals sequence activities and allocate time—a physical space/time dimension of travel), the transportation researcher will be in a position to describe land-use and land-use change on the basis of how the environment is used. The study group is using an existing large scale data base collected by the California Department of Transportation and the Southern California Association of Governments in 1976 that contains information about rural as well as urban travel behavior. Results of the investigation are expected to provide useful information on the

impacts of transportation systems and services available, and associated spatial, economic, and social patterns on various aspects of community development and investment decisions.

### STATUS

A collection of data on economic structure and community development is complete. Several alternative methodologies for the analysis of household activity patterns for subsequent classification analysis and forecasting have been developed. A series of cluster analysis algorithms, used to identify the natural groupings of activity patterns defined by the classification index, is also complete. The data has been used to determine the influence of household characteristics and urban form on household activity patterns.

The work currently in progress includes the analysis of the physical constraint space and the measurement of the effect of restraint policies in activity patterns. A complete analysis and evaluation of the results obtained will follow.

### APPLICATIONS

The results of this investigation have potential use to the State of California, U.S. Department of Transportation, and the scientific community.

At the state level, the detailed analysis will provide CALTRANS and SCAG with useful information on the effects of urban form and activity site locations on travel behavior and urban activity patterns. This research will answer the following questions for State governments:

- 1) What aspects of urban form are most influential upon travel behavior and activity patterns?
- 2) What aspects of economic activities are most influential upon travel behavior and activity patterns?

The research will provide U.S. DOT with a theoretically consistent analysis of the causal relationships between independent descriptors and observed travel behavior and activity patterns for both urban and rural households in a multi-county region.

Finally, this research will provide the transportation research community with a full-integrated analysis of activity patterns that is consistent with the position that household travel behavior is related directly to both the location and intensity of economic activities in various communities.

## NONDESTRUCTIVE EVALUATION OF LONGITUDINAL RAIL FORCE BY ACOUSTIC EMISSION METHOD

### PRINCIPAL INVESTIGATOR

Kanji Ono  
School of Engineering & Applied Science  
University of California, Los Angeles  
405 Hilgard Avenue  
Los Angeles, California 90024

### AMOUNT

1980 - \$110,000  
(\$21,619 in university funds)

### TENURE OF CONTRACT

June 1980 - August 1981

### MONITOR

Harry L. Ceccon, DTS-733  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2373

### ABSTRACT

The objective of this study is to obtain a framework and basic design data for a nondestructive method of rail force measurement. To accomplish this, the study develops a test method which measures longitudinal stress in long lengths of welded rails. This method is based on the phenomenon of magnetomechanical acoustic emission, which arises from the sudden motion of a magnetic domain boundary.

The study develops a prototype instrument that measures, nondestructively, the longitudinal stress in rails, using the magnetomechanical acoustic emission techniques. Both laboratory and field testing are to be performed to evaluate the capabilities and limitations of this approach and the performance of the prototype instrument.

### APPLICATIONS

The information will be useful to improve rail inspection equipment and techniques. The application of better inspection techniques should improve the operating safety of U.S. railroads by helping to reduce the train derailment potential.

## DAMAGE ASSESSMENT AND CONFINEMENT IN OFFSHORE PIPELINES

### PRINCIPAL INVESTIGATOR

Charles D. Babcock  
School of Engineering & Applied Science  
California Institute of Technology  
Pasadena, California 91125

### AMOUNT

1980 - \$77,342  
(\$3,560 in university funds)

### TENURE OF CONTRACT

June 1980 - July 1981

### MONITOR

William A. Gloc, DMT-32  
Research & Special Programs Administration  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-2082

### ABSTRACT

The object of this research is a) to define conditions and parameters under which hazardous buckling failure of undersea pipelines may occur, and b) to provide technical information on preventive measures for The Department of Transportation's use in relation to Federal pipeline safety regulations in 49 CFR Parts 192 and 195. Failure threshold data shall be determined empirically and shall be analytically verified to ascertain the limits of damage a pipeline may sustain without initiation of a propagating buckle. The project focuses on a) quantification of limiting damage such that measures may be specified to avoid a propagating buckle; b) definition of provisions that will arrest an initiated buckle in order to minimize the overall damage; and c) assessment of conditions under which a buckled section will fracture to produce a wet buckle.

**MICROENCAPSULATION FOR TRANSPORTATION SAFETY****PRINCIPAL INVESTIGATOR**

L. Shelbert Smith  
Department of Chemistry  
Central State University  
Wilberforce, Ohio 45384

**AMOUNT**

1979 - \$108,724  
(\$5,876 in university funds)

**TENURE OF CONTRACT**

June 1979 - May 1981

**MONITOR**

Irving Litant, DTS-332  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2517

**ABSTRACT**

A considerable amount of hazardous materials are transported each year by rail, truck, and barge. In spite of safety regulations, each year serious accidents occur in transporting these materials which lead to fires and/or explosions and loss of lives and cargo. The objective of this research project is to study ways in which the danger of fires and explosions can be minimized in the transportation of these hazardous materials. The microencapsulation of fire retardants for coating of packaging containers should provide a greater margin of safety during transportation of these materials. Microencapsulation is a well known process which has been utilized in a variety of processes. This research will utilize this well-known technique

to investigate a variety of capsule materials for encapsulating various fire retardants. Studies are being made on the feasibility of coating containers to minimize the danger of fires and subsequent explosions when accidents do occur. The process can have wide applicability in the packaging industry where hazardous materials are of major concern. In addition, research will be undertaken to study the encapsulation of certain hazardous materials as a technique of improving safety in the transportation of these materials.

**STATUS**

The research has concentrated on the microencapsulation of fire retardants and intumescence compounds for use in the transportation of hazardous materials. The encapsulation of certain materials has been achieved with gelatin and polyvinyl alcohol as the capsule material.

The second phase of the project includes encapsulation of solid materials encapsulation (solid fire retardants and intumescence compounds), and a study of other capsule wall materials for encapsulation of solids, liquid, and use in aqueous and non-aqueous media.

**APPLICATIONS**

This procedure has been used in many applications, but it has not been used in the encapsulation of hazardous materials, fire retardants or intumescence compounds. The later materials are moisture sensitive or deteriorate rapidly when exposed to the atmosphere, but the encapsulation protects them from these conditions without interfering with their effectiveness or purpose. The objective is to incorporate these substances in coatings and other types of paints or adhesives to be applied to containers for protection against fire. The system used in this project so far has been reported in some patent work and published articles. Potential users include the materials laboratory at Wright Patterson Air Force Base.

**ASSESSING THE POTENTIAL FOR INDIVIDUAL ENERGY SAVINGS  
THROUGH COORDINATED TRANSIT PLANNING AND NEIGHBORHOOD  
BUSINESS DISTRICT DEVELOPMENT**

**PRINCIPAL INVESTIGATOR**

Larry L. Earvin  
Southern Center for Studies in Public Policy  
Clark College  
240 Chestnut Street, S.W.  
Atlanta, Georgia 30314

**AMOUNT**

1980 - \$48,000  
(\$11,134 in college funds)

**TENURE OF CONTRACT**

July 1980 - June 1981

**MONITOR**

Ross W. Adams, UTD-10  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4022

**ABSTRACT**

This project analyzes the transportation behavior of individuals in four types of neighborhoods given 1) the presence of a transit facility and a neighborhood business district in the neighborhood, 2) the presence of only a transit facility, 3) the presence of only a business district, and 4) the absence of a transit facility and neighborhood business district within the neighborhood. The analysis is expected to determine whether energy savings accrue more to some individuals in any of these types of neighborhoods than to others.

## SHORT-RANGE OPERATIONS PLANNING MODELS FOR TRANSIT SYSTEMS

**PRINCIPAL INVESTIGATOR**

Mark A. Turnquist  
Department of Civil and Environmental Engineering  
Cornell University  
Hollister Hall  
Ithaca, New York 14853

**AMOUNT**

1980 — \$41,209  
(\$3,505 in university funds)

**TENURE OF CONTRACT**

September 1980 — October 1981

**MONITOR**

Michael R. Couture, DTS-243  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2173

**ABSTRACT**

The objective of this project is to develop simple and usable analytic tools, or a system of tools, to guide management in the search for and evaluation of operating strategies which meet local transit service objectives. The analysis system resulting from this effort is intended primarily for use on single routes or in transit corridors, including a small number of parallel or serial routes. The objectives of the research are achieved by the integration of models of demand and supply in a decision-making framework. The decision framework is designed to aid the manager or analyst to identify and evaluate promising operations alternatives. The system incorporates capabilities for sensitivity analysis to clarify tradeoffs between multiple service characteristics, ridership, and net operating costs. The demand and supply models and the conceptual design for the integrated model system will be developed in the first phase of the research. Development, testing and evaluation of a computerized version of the model system will be performed in the second phase of the research.

## MANAGEMENT OF RAILROAD CAR DISTRIBUTION PRINCIPAL INVESTIGATOR

**PRINCIPAL INVESTIGATOR**

Mark A. Turnquist  
Department of Civil & Environmental Engineering  
Cornell University  
Hollister Hall  
Ithaca, New York 14853

**AMOUNT**

1980 — \$53,774  
(\$2,677 in university funds)

**TENURE OF CONTRACT**

September 1980 — October 1981

**MONITOR**

Dennis H. Terry, RPD-13  
Federal Railroad Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-2608

**ABSTRACT**

The problem of low freight car utilization has plagued railroads for many years. As the costs of equipment continue to rise, this problem becomes more pressing. A key element in any systematic approach to the problem of low car utilization is improving the distribution of empty freight cars. The objective of this research is to synthesize the knowledge gained in previous studies of empty car distribution, and build upon that knowledge to suggest implementable strategies by which railroad management can improve performance in this critical area. The principal focus in this approach is to incorporate appropriate price and opportunity cost information into relatively simple decision-making aids for railroad management. It is not the intent of this research to develop new network optimization procedures to specify routing of empty cars automatically, but rather to incorporate important fundamental ideas from economics and operations research into a synthesis of existing models to produce simpler, more usable, analytic tools which can aid management decision-making.

## A UNIFIED APPROACH TO PERFORMANCE STANDARDS AND FARE POLICIES FOR URBAN TRANSIT SYSTEMS

**PRINCIPAL INVESTIGATOR**

George Kocur  
Resource Policy Center  
Thayer School of Engineering  
Dartmouth College  
Hanover, New Hampshire 03755

**AMOUNT**

1980—\$65,600  
(\$6,249 in university funds)

**TENURE OF CONTRACT**

June 1980 — April 1981

**ABSTRACT**

The development of general service, performance, or fare policies for transit systems requires the recognition of local variations in objectives, resources, costs, and demography. The premise of this research is that these variations are already represented in the urban transportation modeling systems and data bases of many regions. These form a viable starting point for the development of simplified, yet consistent, approaches for analyzing performance levels and fare policies. The techniques developed in this research will be analytical supply/demand equilibrium models whose optima are determined for a range of operating objectives and conditions. The results will be described in a set of operators' and planners' handbooks. A case study using the techniques will be performed, and national policy implications will be outlined.

**MONITOR**

Donald E. Ward, DTS-242  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2741

## FUNDAMENTAL STUDIES IN TRIBOLOGY AS RELATED TO AUTOMOTIVE FUEL ECONOMY

**PRINCIPAL INVESTIGATOR**

S. Ramalingam  
College of Engineering  
Georgia Institute of Technology  
225 North Avenue, N.W.  
Atlanta, Georgia 30332

**AMOUNT**

1980 — \$145,000

**TENURE OF CONTRACT**

July 1980 — June 1981

**ABSTRACT**

Tribo-elements in automotive systems are necessary to the mechanical function and durability of the automotive equipment. They are also a source of significant energy dissipation and therefore cause a reduction of fuel economy. The temperature limitations of tribo-elements also limit engine thermal cycle temperatures which if increased could lead to more efficient engines with the concomitant improvements in fuel economy. This research is an interdisciplinary program (materials/coatings and tribo-mechanics/rheology) directed towards the optimization of the tribo-system (materials surface coating and lubricant rheology). The objective is to be able to reliably predict the frictional losses in tribo-systems of automotive equipment and to increase temperature capability of such systems without loss of acceptable durability.

**MONITOR**

Russel Zub, DTS-323  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
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(617) 494-2056

## AN EVALUATION OF THE POTENTIAL ABILITY OF GEOGRAPHICALLY BASED SHIPPER'S COOPERATIVE ASSOCIATIONS TO PROVIDE BENEFITS TO SHIPPERS IN LOW TRAFFIC DENSITY AREAS OF THE UNITED STATES

### PRINCIPAL INVESTIGATOR

James H. Lemly  
College of Business Administration  
Georgia State University  
University Plaza  
Atlanta, Georgia 30303

### AMOUNT

1978 — \$31,741  
(\$1,681 in university funds)  
1979 — \$20,900  
(\$1,500 in university funds; \$1,000 cooperator share)  
1980 — \$11,500

### TENURE OF CONTRACT

June 1978 — June 1980

### MONITOR

Robert Bruton, P-33  
U.S. Department of Transportation  
400 Seventh St., S.W.  
Washington, D.C. 20590  
(202) 426-4435

### ABSTRACT

This research accepts the fact that there are essentially rural, partially isolated, areas with little comparative economic growth in many parts of the United States. In some of these areas, there is an apparent parallelism between decline in economic activity and weakness in transportation service.

This research hypothesizes that, in some instances, declining transportation service levels may be halted or slowed by the development and effective operation of geographically based shippers' cooperative associations. If this proves to be true, it can have significant policy implications for the nation.

In order to move toward testing this hypothesis, this case study has (1) investigated the pertinent literature to establish

the legal and historical conditions which would confront such associations, (2) located within a suitable study area one or more geographically homogeneous smaller areas suitable for the development of such associations, and (3) reported the findings related to potential successful operations of such associations to the subject areas and to the nation at large. This study did not undertake the establishment of shippers' associations but has provided the basic data necessary to encourage others to do so if the evidence supports such a move. The study areas for the investigation lie within a 29 county grouping in Southwest Georgia. This region fits the definition of non-central, non-dynamic areas and is appropriate as a test area for other similar sections of the United States.

### STATUS

All phases of the project have been completed. An extensive examination of the legal and historical patterns relating to nonprofit shippers' associations was made and submitted to DOT. Also completed is the study of localized transportation patterns in potentially suitable areas, which might effectively, utilize the services of a non-profit shippers' associations. These studies, produced clear evidence that cooperative shippers' associations could be organized and operated beneficially in S.E. Georgia if there was a full understanding of the issues by the shippers in the area, and a desire to organize such associations.

### APPLICATIONS

This research will be useful to all shippers in rural or low density areas. It will help in developing new strategies to improve levels of service, especially in the event of significant deregulation of the motor carrier industry. The Southwest Georgia Planning and Development Commission is supporting the study aggressively and will seek to induce widespread local interest in the research. The Commission is attempting to form a shippers' association. If a viable shippers' association, of the type under consideration here, could be formed, this would lend credence to the view that shippers in low density areas have a useful alternative to being dependent solely upon government regulation of service patterns in low density areas.

DOT and the Department of Agriculture Extension Service are using this research as the basis for further study.

## SURVEY OF BLACK SINGLE-PARENT FAMILY TRANSPORTATION NEEDS

**PRINCIPAL INVESTIGATOR**

James E. Savage, Jr.  
Department of Psychology  
Howard University  
Washington, D.C. 20059

**AMOUNT**

1977 — \$83,000

**TENURE OF CONTRACT**

October 1977 — May 1980

**MONITOR**

Will Terry Moore, HHP-23  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4856

**ABSTRACT**

The number of black single-parent families in the United States is growing at a rapid rate. According to recent Census data (U.S. Bureau of the Census, Current Population Report, Special Studies, Series p. 23, No. 54, "The Social and Economic Status of Black Population of the United States," 1974 and Series p. 23, No. 49, "Population of the United States: Trends and Prospects, 1950-1990"; 1974) there has been a dramatic increase in the percentage of black single-parent families since 1970. This increase has been most prevalent for black single-parent families headed by females. These women, who often are part of the labor force, must serve as mother and father to their children. The bulk of the responsibility for family maintenance (social, emotional, and economical) falls on them. If these parents are the sole wage earners in the fami-

ly, the transportation system demands a larger share of the family income. If these families do not own a car (as is often the case for low-income families), the demand is even greater. Though numerous studies have focused on the relationship of transportation demands to family size, none has focused on the dynamics of single-parenthood as it relates to transportation.

It is hypothesized that the travel demands and choice of residence of black single-parent families are significantly different from those of black two-parent families. If their travel demands are significantly different, then there may be a large travel demand that existing transportation facilities are not able to satisfy.

The objective of this research is to collect new data on travel demands, trip-making, and geographic mobility as they relate to black single-parent family structure. The research seeks to answer quantitatively a set of questions concerning differentiation of black single and black two-parent families with respect to transportation system requirements. A sample of 183 black single female-parent households and 183 black two-parent households from the Metropolitan Washington area, comparable in income, number of children, and residence, have been surveyed.

**STATUS**

All research on this project has been completed; the final report is in preparation.

**APPLICATIONS**

When the final report is finished, the information will be disseminated to the U.S. Department of Transportation, the participating families, Howard University, the Council of Governments, the local District of Columbia government and to professional organizations and other agencies that have inquired about the data. These groups will use the data to plan for the transportation needs of black families. In addition, it is hoped that these results will be reflected in policy and procedures when implementing transportation systems.

## THE DEVELOPMENT AND TEST OF MATHEMATICAL MODELS OF TRAVELER PERCEPTIONS AND DECISIONS

**PRINCIPAL INVESTIGATOR**

Irwin P. Levin  
Department of Psychology  
University of Iowa  
Iowa City, Iowa 52242

**AMOUNT**

1978 — \$61,700  
(\$665 in University funds)

**TENURE OF CONTRACT**

September 1978 — August 1980

**MONITOR**

Mary Lynn Tischer, HHP-22  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-0182

**ABSTRACT**

This research is aimed at providing an in-depth analysis of the perceptual and decision processes underlying traveler behavior. The component processes studied include: (1) the process by which subjective perceptions and evaluations of mode attributes are formed; (2) the trade-off process by which a set of perceived attributes, including both quantitative attributes such as time and cost, and qualitative attributes such as perceived comfort, convenience, and safety, is combined or integrated into an overall evaluation of alternative travel modes; and (3) the process by which subjective evaluations of alternative modes are translated into choice behavior. The research strategy for analyzing these processes includes a combination of laboratory studies and observations of actual traveler choices. The end result will be a set of equations relating mode attributes to traveler choice behavior. This research should lead to an increased understanding of the processes underlying traveler decisions, better forecasting ability, and better assessment and planning of policy decisions.

**STATUS**

Initially the study focused on how the "functional measurement" method of scaling modal attributes can be applied to "soft" or qualitative variables affecting mode choice such as perceived safety, economy, and convenience of flying vs. driving; subjective perceptions of qualitative variables have been related to antecedent objective system attributes and to consequent mode choice behavior. Subsequently, the study centered on new subjective perceptions of time and cost for the work trip are related to objective time and cost values; results showed that most car drivers could not articulate dollars-and-cents cost estimates but generally underestimated driving costs (relative to using mass transit) while travel time was generally overestimated. Furthermore, the extent of overestimation of time was correlated with factors such as modes used and perceived comfort. The implication of these results is that travel demand models must incorporate the functional relationship between objective and subjective time and cost values if their parameters are to be useful for forecasting purposes.

The major part of this project is nearing completion. A mail-back survey included a controlled simulation design to analyze the contribution of a variety of mode attributes on modal evaluations and an analysis of demographics and revealed preference to relate subjective evaluations and personal constraints to actual mode choice decisions. Preliminary results suggest that cost factors are not as important as previously believed. However, recent national and local trends have led the investigator to revise his design to incorporate rapidly changing fuel costs and fuel availability. These factors will thus be studied in greater detail during the remainder of the project.

**APPLICATIONS**

The project will provide practical handbooks describing how the present analyses can be completed quickly and inexpensively in order to have immediate impact on mission applications. New survey techniques have been advanced, and the analysis of the processes underlying travel behavior (e.g., misperceptions of travel time and cost) should have direct policy implications. The research on interpersonal factors affecting the desirability of ridesharing has led to modifications of existing state-sponsored carpool promotional programs in New York and Maryland. The current research should be useful to transportation planners in the State DOT's.

## GEOPHYSICAL GROUTING CONTROL SYSTEMS

### PRINCIPAL INVESTIGATOR

Richard L. Handy  
Department of Engineering  
Engineering Research Institute  
Iowa State University  
Ames, Iowa 50011

### AMOUNT

1979 — \$71,903  
(\$8,740 in university funds)  
1981 — \$46,528  
(\$9,263 in university funds)

### TENURE OF CONTRACT

June 1979 — September 1981

### MONITOR

John R. Sallberg, HRS-11  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(703) 557-5272

### ABSTRACT

Grouting or pumping of hardening fluids into pores in soils and rocks, is useful for in-situ strengthening of weak sub-grade, embankment, and foundation soils, and for sealing off groundwater and strengthening soils and rocks for safer and cheaper tunneling. Yet grouting is underutilized; a major problem is to know where the grout has gone and whether the

grouting was effective, since grout will follow the path of least resistance and often goes far astray from the intended treatment zone. Grouting, therefore, is an art based on inference from pressure and volume measurements.

This research seeks to develop a geophysical system whereby radial movements of the grout front will be monitored at selected depths by electrical resistivity measurements between electrodes at the ground surface. Initial studies have been made which show the feasibility of the method, but further research is necessary to find the most effective geometry for the electrode array and a suitable data reduction method.

Initial research involves model studies whereby a check on grout penetration will be obtained from buried electrical "grout detectors," as well as inferred from the trail surface resistivity measurements. Subsequent work involves the use of the surface resistivity method to monitor grout movements on an actual job in the field, and the use of cross-hole and down-hole seismic methods to determine grouting effectiveness after completion.

### STATUS

This project is entering the second phase which involves testing at particular sites—testing systems of electrical resistivity measurements between electrodes that will monitor radial movements of the grout front when grout is pumped into soil for strengthening purposes. The result will allow a choice of the system which can best monitor the grout front.

### APPLICATIONS

The results of this research are expected to be applied in the areas of highway and railbed construction, tunneling, and subgrade/embankment strengthening, where the refined monitoring system will permit more accurate measurement of the spatial progress of the grout.

## AN ANALYSIS OF TRANSPORTATION LAND USE INTERACTIONS

### PRINCIPAL INVESTIGATOR

Richard S. P. Weissbrod  
John Hopkins University  
Charles and 34th Streets  
Baltimore, Maryland 21218

### AMOUNT

1978 — \$60,000  
(\$6,158 in university funds)

### TENURE OF CONTRACT

September 1978 — May 1980

### MONITOR

Bruce D. Spear, DTS-243  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2276

### ABSTRACT

The objective of this research is to explore several alternative conceptual approaches to the subject of transportation/land use interactions, through an in-depth analysis of the recent Baltimore household transportation survey. The analysis reviews several concepts suggested by Zahavi, including the travel time, travel money budgets and the interactions between travel and urban structure and extend them to a more general framework, in order to encompass other

hypotheses and further possible developments. Emphasis is placed on exploring parts of a comprehensive model rather than developing a fully operational model of transportation/land use interactions.

### STATUS

Zahavi's concepts, and his extensions to the Unified Mechanism of Travel model, include the application of observed regularities in travel time and money budgets as constraints on travel choices in urban areas. The regularities observed by Zahavi in travel budgets including their transferability between cities and over time in a country, were based on data stratified by broad population segmentation. Preliminary results of the Baltimore one-day survey data, analyzed at disaggregate levels and controlled for a wide range of socioeconomic, transportation system and location characteristics, suggest that the travel time and money expenditures do show regularities, although significant variations in both budgets are observed at the level of individual households. Further analysis is in progress in order to identify, explain, and perhaps reduce the ranges of variations.

### APPLICATIONS

The research findings will be useful to a wide range of individuals, including transportation planners, land-use planners, and local, state and federal policymakers. If the regularities in the travel time and travel money expenditures are fully verified, their incorporation in new travel models, such as the Unified Mechanism of Travel (UMOT), promise to revolutionize transportation analysis and planning by reducing the need for data collection, expensive computer processing, and tediously long application periods, as well as being more effective for policy analysis at the local, state and federal levels.

## A COMMUNITY MODEL FOR HANDLING HAZARDOUS MATERIALS TRANSPORTATION EMERGENCIES

### PRINCIPAL INVESTIGATOR

Eugene R. Russell  
Department of Civil Engineering  
Kansas State University  
Manhattan, Kansas 66506

### AMOUNT

1979 — \$156,488  
(\$18,546 in university funds)  
1980 — \$7,635

### TENURE OF CONTRACT

August 1979 — September 1981

### MONITOR

W.J. Burns, P-24  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4476

### ABSTRACT

Riley County, Kansas, and its principal urban area, is being used as a model of medium to small city and small town areawide organization for development of consistent emergency procedures for dealing with potential transport accidents involving the release of dangerous materials and/or the resulting fire or explosion. Within a model organizational frame, a risk analysis model will set forth a comprehensive set of procedures for a community to assess its own risk potential from transport accidents and thus be in a position to develop a set of emergency procedures consistent with the risk. Long-range planning models to minimize the risk, analogous to flood plan zoning minimizing flood disasters, will be incorporated. Finally, available hazardous materials transportation course material

will be adapted to local use and a pilot program to train a cadre of individuals familiar with the material will be developed. The model for organization, risk analysis, consistent range of counter-measures and associated local training materials can be used as models for any medium to small city, county, and/or rural area in the U.S. to develop its own total program geared to the level of its risk for any hazardous materials transportation emergency which may occur.

### STATUS

Phase I of the three-phase project is nearing completion. Available literature has been collected. Synthesis of the literature and the sample of states' laws, including an in-depth review of Kansas laws, will be completed soon. A large quantity of data, supplemented by reports on seven years of accidents in Kansas, has been obtained from the Kansas Department of Health and Environment. The main product of Phase I, a User's Manual with Guidelines for a Risk Analysis Model, has been completed. Additional final testing and evaluation of the Risk Analysis Model are underway.

Phase II of this project will produce a Community Preparedness Model that can be used as a guide for any small city to 1) develop an efficient organizational structure within which any given hazardous materials transportation emergency plan can operate and 2) develop long-range planning approaches to minimize the potential for hazardous materials transportation emergencies.

Phase III will consist of producing training manuals and related workshop materials for local cadre use.

### APPLICATIONS

The Phase I report will be used by professionals interested in the transportation of hazardous materials. The Risk Analysis User's Manual will be used by local officials in communities of 50,000 people and smaller. The products of Phases II and III will also be used by both researchers and community officials to aid in implementing a transportation emergencies plan to handle hazardous materials. The results of this research should help to improve the safety and reduce the risk of transporting hazardous materials across the nation.

**UNIVERSITY OF KENTUCKY**

**CONTRACT NO: DT-RS-56-80C-00016**

## **TIRE/ROADWAY INTERACTION AND ITS EFFECTS ON VEHICLE SAFETY TRADE-OFFS**

### **PRINCIPAL INVESTIGATOR**

Andrew F. Seybert  
Department of Mechanical Engineering  
University of Kentucky  
Lexington, Kentucky 40506

### **AMOUNT**

1980 -- \$66,500  
(\$3,500 in university funds)

### **TENURE OF CONTRACT**

June 1980 — May 1981

### **MONITOR**

Fred M. Romano, HRS-42  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4980

### **ABSTRACT**

This project will attempt to identify and formulate key research problems related to tire dynamics, deformation, and stress analysis. This will be accomplished by reviewing the state-of-the-art for analytical concepts of dynamical elasticity in tire mechanics. In order to better understand the relation between the mechanical behavior of rubber materials and tire noise, this project will investigate basic fiber reinforced elastic systems under static and dynamic loadings.

### **APPLICATIONS**

This research will lead to the development of new concepts in tire design, resulting in increased highway safety and control of tire/pavement noise.

## FRACTURE ANALYSIS OF PIPELINES

### PRINCIPAL INVESTIGATOR

Fazil Erdogan  
Department of Mechanical Engineering  
Lehigh University  
Bethlehem, Pennsylvania 18015

### AMOUNT

1978 — \$50,300  
(\$15,616 in university funds)  
1979 — \$99,339  
(\$17,384 in university funds)

### TENURE OF CONTRACT

September 1978 — August 1981

### MONITOR

Oscar Orringer, DTS-744  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2419

### ABSTRACT

This is a research program for studying fracture initiation and propagation in pipelines which may contain a circumferential flaw such as a defect in the girth weld. During the first year, the solution of the problem of a pipe containing a circumferential through crack has been obtained and that containing a part-through crack with a fully-yielded net ligament was formulated. Also, in order to clarify the question of leak vs. break in pipes certain elastic-plastic problems for a plate with a part-through crack will be considered. Second and third year programs will involve experimental as well as theoretical research. Basic plate experiments are being carried out in order to test the validity of fracture stability models which have been developed during the first year for cylinders and plates with a part-through crack. The particular weld and base materials of pipes will be characterized with regard to their fatigue and

fracture behavior, the fixtures for the pipe bending experiments will be designed, and elastic-plastic solution of the part-through crack problem for the cylinder will be obtained. the elastic-plastic axisymmetric problem for a relatively thick-walled cylinder will be considered during the second and third years. Also during the third year the experimental program for the welded pipes will be carried out, a practical solution for a circumferential surface crack in elastic pipes will be developed, and final evaluation of various failure theories will be made in light of the experimental and theoretical results obtained in the program.

### STATUS

The solutions to the problems of a pipe with a circumferential through crack, a plate containing a surface crack with a fully-yielded net ligament, and the elastic plastic plate with a long part-through crack have been completed. The problem of a pipe with a part-through crack and plastic net ligament is being studied. Review and further theoretical work regarding the fracture instability in cracked plates and cylinders is being carried out.

### APPLICATIONS

This project is the result of a continuing effort by DOT to improve its regulations. The current pipeline welding code is essentially a quality control code based on a level of performance which can be reasonably achieved by trained welders in the field. Radiographs are used to examine weld quality. This code, however, is arbitrary since it does not take into account the grade of steel and welding materials involved, pipe dimension, pressure, temperature and other external loads. This research will relate flaw size to all the aforementioned factors so that a more realistic and consistent code can be established.

The effort is fully coordinated with the pipeline welding research being conducted by the Materials Transportation Bureau at the National Bureau of Standards. A code of this type could have saved millions of dollars during the construction of the Trans Alaskan Crude Oil Pipeline. The results of this research may also be applied in establishing design and inspection codes for other relatively thin-walled pressurized containers such as tank cars.

## RELIABILITY OF ULTRASONIC WELD INTERROGATION METHODS

### PRINCIPAL INVESTIGATOR

Steven Serabian  
Department of Mechanical Engineering  
University of Lowell  
One University Lane  
Lowell, Massachusetts 01854

### AMOUNT

1979 — \$63,309  
(\$5,573 in university funds)  
1981 — \$55,519  
(\$4,846 in university funds)

### TENURE OF CONTRACT

June 1979 — May 1981

### MONITOR

Robert P. Ryan, DTS-733  
U. S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2348

### ABSTRACT

The objective of this research involves a study of the general nature of the available weld interrogation procedures and to assess their usefulness in terms of their reliability of producing valid flaw characterization—e.g., size, orientation and location. The most promising techniques will be explored in detail and means sought to increase their reliability as flaw detection processes. Special attention will be given to those methods that are amplitude independent. Both analytical and experimental phases with simulated weldment flaws will be involved.

### STATUS

The first year of research was completed as scheduled. This phase considered mathematical modeling and experimentation validation of the detection/characterization processes used in the ultrasonic flaw detection method. The experimental portion used ideal, flat, and smooth flaws as simulated by drilled flat bottom holes in homogeneous materials.

The second phase of the project calls for application of the results of Phase I. This phase will consider real or fabricated flaws in welds.

### APPLICATIONS

The results of this research will be useful in rail inspection as well as in other weld applications.

## DEMAND—RESPONSIVE DECENTRALIZED URBAN TRAFFIC CONTROL

### PRINCIPAL INVESTIGATOR

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Department of Civil Engineering  
University of Lowell  
One University Avenue  
Lowell, Massachusetts 01854

### AMOUNT

1979 — \$67,120  
(\$3,456 in university funds)  
1981 — \$59,918  
(\$3,056 in university funds)

### TENURE OF CONTRACT

July 1979 — October 1981

### MONITOR

John MacGowan, HRS-32  
Federal Highway Administration  
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Washington, D.C. 20590  
(202) 557-5224

### ABSTRACT

Common logic as well as analytical studies indicate that demand-responsive traffic control can very significantly improve urban street network performance. Yet effective traffic responsive control has eluded transportation system researchers for many years, the main stumbling blocks being the inadequacy of predicted data from past traffic behavior and the unmet requirements for real-time optimal control. The purpose of this research is to investigate innovative approaches to the problem based on the development of on-line traffic models, which relax the reliance on predicted data, and decentralized optimization strategies, which are amenable to realtime execution. The new methodologies will be particularly

suited for implementation via emerging microprocessor technologies.

The research in Phase I will develop the models and optimization procedures and refine them via simulation studies. The objective of Phase II is to test the developed methodologies under simulated field conditions, derive a field test plan, and investigate system design requirements including alternative hardware configurations.

### STATUS

Phase I has been completed. An On-Line Traffic Model has been developed for use in a demand-responsive decentralized urban traffic control system. A demand-responsive decentralized optimization procedure for traffic signal control has also been developed using Dynamic Programming (DP) optimization, which will determine the sequence of light switching times that will minimize the aggregate performance index over the entire horizon. The testing and refinement of the traffic model and optimization procedures through analytical techniques and simulation continues.

### APPLICATIONS

This new approach to demand-responsive urban traffic control, constitutes a significant advance in the state-of-the-art and will eventually lead to a wide scale implementation of its results. The results of this research will benefit all groups connected with urban traffic control such as highway users (motorists and transit users), traffic engineers, and control equipment manufacturers.

It is expected that the methodologies and techniques developed in this project will form the basis for a new generation of urban traffic control systems which will combine the potentially tremendous capabilities of decentralized microprocessor-based hardware with suitably matched advanced software.

The Federal Highway Administration has assisted in using the NETSIM model; the Miami Traffic Control Center has assisted in furnishing real-time traffic data. Communication has also been made with the Massachusetts Department of Public Works, the Toronto Traffic Control Center, and Computer Systems Engineering.

## ASSESSING LOCAL DEFICIT AND SOCIAL SERVICE AGENCY USER CHARGES FOR RURAL PUBLIC TRANSPORTATION

### PRINCIPAL INVESTIGATOR

John Collura  
School of Engineering  
University of Massachusetts  
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### AMOUNT

1978 — \$55,741  
(\$7,647 in university funds; \$3,833 cooperator share)  
1979 — \$51,980  
(\$17,384 in university funds)  
1980 — \$8,175

### TENURE OF CONTRACT

September 1978 — November 1980

### MONITOR

Douglas McKelvey, HHP-26  
Federal Highway Administration  
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Washington, D.C.  
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### ABSTRACT

Several questions need to be addressed in order to determine whether demonstration projects under the FHWA Rural Public Transportation Demonstration Program can continue on a permanent basis. Two questions are: 1) How should the local share of the deficit be apportioned among towns receiving service? and 2) How should user charges for participating social service agencies be determined?

The objective of the research is to develop and test alternative methodologies to: a) apportion the deficit among towns receiving service as part of a region-wide public transportation program, and b) determine user charges for participating social service agencies.

### STATUS

The work in the first year resulted in the development and preliminary testing and evaluation of alternative cost allocation procedures for rural transportation programs. The procedures were tested with data, provided by the Barnstable

County Public Transportation Program, which describe the socio-economic, resident and trip characteristics of 100% of all users of the demand-response service and were collected by the County using a serially numbered rider identification pass.

The procedures incorporate the following variables, either individually or in combination; population (general and elderly); real estate valuation; amount of service provided (passenger trips, passenger miles, vehicle miles, and vehicle hours); number of social service agencies; and number of agency clients. Based on the data analysis, the various procedures were evaluated in terms of their ease of implementation and ability to produce equitable results.

The research during the second year included the testing of cost allocation procedures in rural sites. Sites were selected to include situations where costs are to be apportioned among towns, among social service agencies, and in combinations of both. Care was taken to insure that a variety of service types were represented (e.g., fixed route, demand-response, and subscription).

The case studies have been prepared, reviewed, and synthesized. A study of the equity issue was also conducted. The management of each case study site will be asked to comment on the reports prepared for each site, and to describe any problems they may have encountered concerning implementation of cost allocation procedures; the results will be incorporated into the synthesis.

### APPLICATIONS

The final product of this research, a cost allocation user's manual, will be useful to local and regional transportation planners and engineers who are currently implementing regionwide public transportation programs. The manual will enable officials to select from alternative procedures based on local needs and requirements. The manual will also be useful to State DOT's and human service agencies which provide technical assistance to local governments.

The Nueces County Community Action Agency in Corpus Christi, Texas has been using the projects report, "Assessing Local Deficit and Social Service Agency Charges for Rural Public Transportation" for guidance in developing procedures for application to a new transit system. Each case study site has been sent a copy of these guidelines for review and use as a resource in the future.

Interest in the research results and assurance of support during the research program have been expressed by coordinators of several transportation and human services in Massachusetts. The Cape Cod Regional Transit Authority was a cooperator on the project in 1978.

## PERFORMANCE LIMITS OF RAIL PASSENGER VEHICLES: EVALUATION AND OPTIMIZATION

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1977 — \$70,000  
1978 — \$71,154  
1979 — \$26,354  
1980 — \$73,000

### TENURE OF CONTRACT

July 1977 — October 1980

### MONITOR

Richard L. Scharr, RRD-21  
Federal Railroad Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9665

### ABSTRACT

The objective of this research is to identify the dynamic performance capability of conventional and innovative passenger truck designs. During the first year appropriate analytical models were adopted and extended to allow the prediction of rail vehicle ride quality, stability, and curving performance. Ride quality is important from a passenger acceptance point of view; stability and curving performance are important with respect to vehicle track maintenance and safety. Dynamic performance models of passenger vehicles, performance indices and preliminary performance data was established. The models developed are capable of analyzing conventional trucks as well as innovative designs such as the new radial truck concept.

The second year's research consisted of defining, in an engineering sense, the performance boundaries (hunting, curving, derailment, ride quality, wheel-track force levels, etc) of current and proposed passenger truck configurations. That work compared the performance boundaries of conventional, optimized conventional, and radial trucks to determine the performance limits of each class of passenger truck. The third year's effort concentrated on a continued investigation of optimized passenger vehicle performance, as well as the very important area of dynamic model validation, i.e., comparing the theoretical model's predictions with actual field test results.

This validation effort resulted in an improved model that rail industry users can utilize with confidence. In addition, the current research continues the cooperative effort with the German firm M.A.N., focusing on the feasibility of active control of passenger rail vehicles.

### STATUS

Prior research efforts focused on the comparison between conventional and radial trucks, particularly with regard to stability and curving. A detailed comparison showed that the radial truck is capable of providing significant performance improvements over the conventional configuration. Although the radially interconnected truck is an example of innovative truck design, there are many possible alternative configurations. It has been shown that there are a limited number of suspension parameters that completely define the dynamic performance of the general truck. Two fundamental papers have been prepared which describe the basic stability and curving mechanics of rail vehicles, as well as compared the performance limits of radial and conventional designs.

The second year's cooperative effort between M.I.T. and the German organization of M.A.N. resulted in a joint report summarizing MIT's work on passive systems and the German effort on active systems.

The third year concentrated on generic vehicle performance, model validation, and preliminary assessment of active control. The final effort to compare the developed models with field data to be obtained from the DOT Transportation Test Center in Pueblo.

### APPLICATIONS

The two major Intercity truck manufacturers, Budd Inc. and GSI, have followed the research and expressed an interest in the work being done. Budd has provided data on their existing designs and has used the models in the design of a new truck.

This research is being directly monitored by the Federal Railroad Administration and is being closely followed by AMTRAK, which has supplied ride quality data from previous tests that they have conducted. The performance data generated by this research will provide direct information to help select performance specifications for new equipment and also to help design vehicles to meet these specifications.

MIT is also part of an international cooperation agreement with the Federal Republic of Germany and the company M.A.N. To date there has been an exchange of information under an agreement called "Optimal Interconnections." The first year's report of this project was translated into German by M.A.N. and they also translated their report on active suspensions into English. As the Germans are planning hardware tests, this cooperative agreement could provide extremely valuable information for current and upcoming rail research.

## UTILIZATION OF VEHICLE, LABOR, AND FIXED FACILITY RESOURCES IN MULTI-MODEL TRANSPORTATION SYSTEMS

**PRINCIPAL INVESTIGATOR**

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Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

**AMOUNT**

1977 — \$58,000

**TENURE OF CONTRACT**

August 1977 — August 1980

**MONITOR**

Sherwood C. Chu, DPB-25  
Research and Special Programs Administration  
U.S. Department of Transportation  
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(202) 426-2022

**ABSTRACT**

The objectives of this research are to develop priorities for specific problem-oriented research to increase transportation

system efficiency and service. The research includes exploratory work to further develop the theory of the utilization of vehicles, labor, and fixed facilities in the transportation systems. Case studies have been conducted to test and refine the methods developed in the research. Initial developments expand on previous analyses of the economics of the vehicle cycle.

The research is problem-oriented. The product of the research will be a report containing (a) recommended priorities for specific problem-oriented research to increase transportation system efficiency and service; and (b) a theory of the utilization of vehicles, labor and facilities in transportation systems and its application to issues analyzed in the case studies, and a discussion of how this theory was utilized in developing the recommendations.

**STATUS**

A final report is in preparation.

**APPLICATIONS**

The research furthers the understanding and theory of multi-modal transportation systems. The results will be of value in further transportation research efforts and in current transportation planning.

## UNDERSTANDING, PREDICTION, AND EVALUATION OF TRANSPORTATION RELATED CONSUMER BEHAVIOR

**PRINCIPAL INVESTIGATOR**

Stephen Lerman  
Transportation Systems Division  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

**AMOUNT**

1977 — \$69,000  
1978 — \$70,000

**TENURE OF CONTRACT**

September 1977 — September 1979

**MONITOR**

David Rubin, DTS-24  
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Transportation Systems Center  
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**ABSTRACT**

Development of highway maintenance standards and justification of maintenance expenditures have traditionally been based to a large degree upon combinations of judgment, experience and existing practice. Very little has been done in the past to explore systematically the effects of changes in maintenance policy on costs and road performance. However, the increasing need for maintenance, and higher costs of providing maintenance services, have recently focused attention on better management practices to define maintenance demands and establish priorities for maintenance activities. The objectives of this research are to investigate and develop (1) numerical measures of maintenance levels of service, or quality standards; (2) quantitative models to predict the condition or deterioration of specific road features as a function of the relevant physical, environment, and traffic factors; and (3)

quantitative models to assess the impacts of maintenance performance in the areas of preservation of investment, user consequences, and accident prediction.

**STATUS**

Review of the literature has been completed in the areas of existing maintenance quality standards and patterns of maintenance expenditures. All of these findings have been documented in three working papers submitted to the DOT monitor. Now underway are studies in two areas: (1) development of condition (or deterioration) models and quality standards required under the demand-responsive approach; and (2) comparisons among maintenance needs, maintenance expenditures, and changes in highway condition inventories as reported nationwide over the past ten years. The building of models to predict the impacts of maintenance performance will follow.

Preliminary results of this research were included in a paper presented at the AASHTO Maintenance Workshop at Hilton Head in June 1980, and will be published in the proceedings of the workshop. This paper is available for distribution.

**APPLICATIONS**

The results of this project will be applied, first, in maintenance budgeting at the State level, in which impacts of maintenance may be assessed against costs, to establish priorities and to defend projected levels of maintenance expenditure. The ideas from which this project evolved have been implemented within the maintenance budgeting component of the Massachusetts Maintenance Management System.

The second area of application is in the development of maintenance and rehabilitation policies and programs at the State and Federal levels. Issues of maintenance vs. capital investments, competition for funds among maintenance activities, and deferred maintenance are some of the management questions that can be addressed using the methods being developed for this study.

Maintenance engineers at both the Federal and State levels appear to be interested in this work. Inquiries have come from Washington State, Louisiana, Kentucky, Alabama, Wisconsin and Georgia; from New Brunswick Province, Canada; and from other university and private consulting groups.

## DEVELOPMENT OF QUALITY STANDARDS AND IMPACT MODELS FOR HIGHWAY MAINTENANCE

### PRINCIPAL INVESTIGATOR

Fred Moavenzadeh  
Department of Civil Engineering  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

### AMOUNT

1979 — \$73,300

### TENURE OF CONTRACT

July 1979 — June 1981

### MONITOR

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(202) 426-4476

### ABSTRACT

The objective of this research is to evaluate the impact of a variety of transportation policies by developing, validating,

and utilizing a set of behaviorally sound disaggregate choice models. Models have been developed using the disaggregate data set for Minneapolis-St. Paul. The research emphasizes two areas: the dynamics of residential mobility, location, and other long-run household choices; and the daily time budgeting and activity scheduling processes. The expected product of the research is an extensive set of policy tests which explore a range of both long and short-run transportation options. In addition, significant improvements in currently available models used by various transportation planning agencies will be achieved by utilizing such models.

### STATUS

An extensive literature review has been completed. Models for both the long-run household choices and daily time budgeting and activity scheduling have been calibrated. Computer programs which use these models to make forecasts of the impacts of various policies have been written and tested. Validation against base year data has been conducted, and where necessary, components of the models have been recalibrated. Forecasts of the effects of various transportation and related policies on time budgets and activity schedules have been conducted, and documentation of the results is nearly complete. Comparable forecasts for long-run household choices will also be conducted.

## MODELLING AND CONTROL OF SPARK-IGNITED INTERNAL COMBUSTION ENGINES

### PRINCIPAL INVESTIGATOR

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Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

### AMOUNT

1979 — \$287,100

### TENURE OF CONTRACT

September 1979 — August 1981

### MONITOR

Robert A. Husted, DPB-25  
Research and Special Programs Administration  
U.S. Department of Transportation  
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Washington, D.C. 20590  
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### ABSTRACT

This research is a three-phase effort on both theoretical and experimental modelling and control of spark ignition engines during transient speed and load changes. The focus is directed at optimizing fuel economy subject to performance and exhaust emission (HC, CO, and NO) constraints during transient operation comparable to the driving cycle in the EPA Federal test procedures. A new methodology shall be developed for modelling transient fuel consumption and transient exhaust emission generation based on an analytical approximation of physical principles. This approach leads to non-linear ordinary

differential equation models with specified state space structure but certain unknown parameters. Maximum likelihood techniques will be used to determine parameter values from experimental data. Interaction between the models, experiment design and identification software will be analyzed to optimize sampling and instrumentation procedures. From these models, several control system approaches will be evaluated which employ coordinated computer-based feedback control of throttle, spark advance, air-fuel ration and exhaust gas recirculation and exhaust emission after treatment process variables.

### STATUS

New state-space models for cylinder combustion and induction have been obtained. The maximum-likelihood parameter estimation method was evaluated on the combustion model using experimental data from a single cylinder engine.

There has been a slight change in focus in experimental components of the program. The researchers are currently revising their work plan to focus on a new technique for transient dynamic control of air-fuel ration in spark ignited, fuel injected engines, using in part, the models developed in the first year's study. A paper on the thermodynamically based cylinder combustion model is currently being prepared for presentation at the 1980 ASME winter meeting.

### APPLICATIONS

This research will be of direct benefit to basic research studies of automotive vehicle and engine control systems. Borg Warner Corporation has expressed interest in our modelling effort as part of their studies in transmission control system studies. General Motors electronics division has an active interest in the control's area and has had some interest in the approach of this project.

## ESTIMATION DATA COLLECTION SCHEMES FOR DISAGGREGATE TRAVEL DEMAND MODELS ESTIMATION

**PRINCIPAL INVESTIGATOR**

Yosef Sheffi  
Department of Engineering  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

**AMOUNT**

1980 - \$75,000

**TENURE OF CONTRACT**

August 1980 - July 1981

**MONITOR**

Larry Quillian, UPM-20  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
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(202) 426-9271

**ABSTRACT**

The objective of this research is to find techniques to reduce the high cost of data collection needed for estimating travel demand models. By developing techniques for collecting data which maximize the statistical information from each data point, statistically efficient sampling strategies can be derived. Such techniques would make the most efficient use of a given data collection budget and reduce the sample size (and therefore the cost) needed in order to get a predetermined degree of accuracy. This research methodology is based on recent work using optimal bayesian updating. The focus of this project is on sampling techniques for discrete choice models. However, sampling techniques for different model forms will be reviewed. The methodology will be applicable to the problem of model transferability as well.

## APPLICATION OF ACTIVE AND PASSIVE SUSPENSION TECHNIQUES TO IMPROVE HIGH SPEED GROUND VEHICLE PERFORMANCE

### PRINCIPAL INVESTIGATOR

J.K. Hedrick  
School of Engineering  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

### AMOUNT

1980 - \$90,000

### TENURE OF CONTRACT

September 1980 - August 1981

### MONITOR

Richard L. Scharr, RRD-21  
Federal Railroad Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9665

### ABSTRACT

The purpose of this research is to develop and evaluate active and nonlinear passive suspension solutions to high speed passenger vehicle problems and to assess their practicality. Such recent advances in control hardware as the availability of inexpensive and reliable microprocessors, and such advances in control theory as improved estimation and identification, offer important potential solutions to ground vehicle ride quality, stability, and curving problems.

In the first year, active and improved nonlinear passive suspension designs for the lateral ride quality problem will be evaluated. Ride quality models will be extended to include essential nonlinearities and then validated with measurements taken aboard an AMTRAK vehicle. The validated model will then be used to evaluate active and passive suspension alternatives. Along with the ride quality analysis, the potential improvements to lateral stability and curve negotiation will be evaluated.

The second year of the research consists of comparing the active and improved passive designs and the evaluation of alternative hardware configurations such as pneumatic and hydraulic actuators.

The third year consists of a prototype design and total simulation of the proposed configuration and recommendations for revenue application.

**STRATEGIES FOR IMPROVING RAIL CAR DISTRIBUTION:  
A STUDY OF OVERCOMING ORGANIZATIONAL AND INSTITUTIONAL  
BARRIERS TO INNOVATION**

**PRINCIPAL INVESTIGATOR**

Joseph Sussman  
School of Engineering  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

**AMOUNT**

1980 - \$107,000

**TENURE OF CONTRACT**

June 1980 - May 1981

**MONITOR**

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(202) 426-2608

**ABSTRACT**

Car distribution is a major operational function throughout the U.S. railroad industry. Attempts to improve this process, however, have met with institutional and organizational barriers to innovation. The purpose of this research is to assess the readiness to accept change and the capability to implement change in the car distribution process in the railroad industry. Innovations to this process shall be considered from the viewpoint of 1) the aspects of the organizational system that should be considered in the innovation process, and 2) the payoffs involved in implementing specific changes in the car distribution process. Those innovations which are considered to be most beneficial and can feasibly be implemented shall be examined in greater detail. Finally, strategies for implementing these innovations will be developed.

## ADVANCED TRANSPORTATION ACCIDENT CASUAL MODELS

### PRINCIPAL INVESTIGATOR

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College of Engineering  
University of Michigan  
Ann Arbor, Michigan 48109

### AMOUNT

1980 - \$94,020  
(\$4,722 in university funds)

### TENURE OF CONTRACT

September 1980 - August 1981

### MONITOR

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### ABSTRACT

Recent developments in multivariate analysis, particularly in the area of multidimensional contingency table analysis, have yielded new statistical techniques which can be used in traffic accident research. This research will utilize advanced statistical techniques to identify the relationships between traffic accident occurrence and highway characteristics, concentrating on an example concerning roadway shoulders. An objective of the research is to improve the use of such techniques in predicting the occurrence and severity of transportation accidents. The results will be important in improving highway design characteristics to reduce accidents.

## A STUDY OF DIESEL SPRAY CHARACTERISTICS AT HIGH INJECTION PRESSURES

### PRINCIPAL INVESTIGATOR

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Department of Mechanical Engineering  
University of Michigan-Dearborn  
4901 Evergreen Road  
Dearborn, Michigan 48128

### AMOUNT

1980 - \$52,000  
(\$2,439 in university funds)

### TENURE OF CONTRACT

May 1980 - April 1981

### MONITOR

Thomas J. Trella, DTS-323  
U.S. Department of Transportation  
Transportation Systems Center  
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### ABSTRACT

It is believed that high fuel injection pressure may help to improve thermal efficiency and pollution levels found in today's direct injection diesel engines. At this time, very little is known about the characteristics of fuel spray and how these characteristics alter during the injection process. The objectives of this research are 1) to identify the dependence of diesel spray characteristics at high injection pressures on a) nozzle configurations, b) air swirl, and c) downstream gas pressures; and 2) to correlate these results so that the correlations can be used to design fuel injection equipment and combustion chambers for optimum performance.

### APPLICATIONS

This research will be highly beneficial in determining the design and operating parameters of fuel injection equipment for a set performance goal on an engine. In addition, the results obtained in this research will be useful in developing sophisticated combustion models to predict diesel engine performance.

## DEVELOPMENT AND EVALUATION OF OPTIMAL CONTROL STRATEGIES FOR LARGE SCALE URBAN TRANSPORTATION NETWORKS

### PRINCIPAL INVESTIGATOR

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University of Minnesota  
Minneapolis, Minnesota 55455

### AMOUNT

1978 - \$60,000  
(\$6,167 in university funds)  
1979 - \$67,000  
(\$5,830 in university funds; \$6,040 cooperator funds)  
1981 - \$98,000

### TENURE OF CONTRACT

June 1978 - November 1980

### MONITOR

Joseph Koziol, DTS-721  
U.S. Department of Transportation  
Transportation Systems Center  
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### ABSTRACT

Work has been undertaken for the development and evaluation of control strategies for high volume urban transportation networks. Fundamental analysis was performed to describe mathematically the formation and dissipation of queues at signalized intersections as a function of the demand, the intersection characteristics and the control decisions. This was accomplished by macroscopic examination of the shock waves generated at the intersection due to the intermittent service of traffic by the signal. The results were extended to a system of intersections, and real time as well as pretimed policies based on the improved queue dynamics were developed. Numerical examples were presented based on real life situations, and comparisons with the existing control schemes by means of simulation were performed. It is believed that the queue dynamics not only result in improved control schemes, but also in a better understanding of the mechanics of the "inner-workings" of traffic.

### STATUS

The following tasks have been accomplished:

1. Development of a rigorous mathematical model describing the formation and dissipation of traffic queues at isolated signalized intersections, with the model then being employed in developing a real-time control scheme for a congested isolated intersection; a pre-timed control scheme has also been devised for such intersections.
2. Preparation of numerical examples based on data collected at actual intersections, with simulation results showing that the proposed control policies are superior to the existing control schemes.
3. Extension of the theory of traffic queue dynamics for a system of intersections in succession.
4. Development of a control scheme, along with numerical examples based on the above results and comparison with existing control schemes.
5. Completion of testing of Demand Prediction Algorithms is anticipated.

### APPLICATIONS

The design of truly effective automated urban traffic control systems is hampered by a lack of adequate mathematical models to represent the flow of automobiles over a signalized grid. This research will result in the development of such models. The results will be applied for optimal control of traffic signals. The traffic models will be used for the development of new signal control strategies, and simulation and evaluation of signal control strategies.

The results will be of use to federal, state and local traffic engineers and the traffic control industry, particularly those persons associated with real-time traffic control systems. Potential users include transportation planners in Brazil and Poland, as well as throughout the U.S.

The City of Minneapolis is a cooperator on the project, providing the free services of one Traffic Engineer who is being advised on the development of the theory. The City also provides data, and assists in the testing of the control strategies.

## RELIABLE DECENTRALIZED CONTROL STRATEGIES FOR FREEWAY REGULATION

### PRINCIPAL INVESTIGATION

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Department of Electrical Engineering  
University of Minnesota  
Minneapolis, Minnesota 55455

### AMOUNT

1979 — \$50,000  
(\$7,242 in university funds)

### TENURE OF CONTRACT

August 1979 — September 1980

### MONITOR

Joseph Koziol, Jr., DTS-721  
Transportation Systems Center  
U. S. Department of Transportation  
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(617) 494-2014

### ABSTRACT

In order to improve traffic flow on an urban freeway system, it is becoming common to use control techniques that regulate the on-ramp traffic and advise motorists of

downstream traffic conditions and possible diversion routes. Such control techniques can operate in a centralized mode or in a decentralized mode. The use of decentralized architecture offers advantages in reliability and stability. The emphasis of this study is thus to investigate the application of new decentralized control structures for freeway regulation. A comparative evaluation of various decentralized structures and estimation and control algorithms is being performed. Computational and data communication aspects are also being examined.

### STATUS

The majority of the work on this project has been completed. Various models describing the flow of vehicles on a freeway were examined, and an appropriate model was selected for a decentralized control strategy. This mathematical model was examined as the basis for developing completely decentralized control structures and also control structures with a multilevel configuration. The contractor then used the models and control schemes to show how they can be extended to stable and reliable control/estimation algorithms for the freeway problem. The conclusion was that the necessary estimation of traffic parameters required for the generation of ramp controls, is best obtained in a totally decentralized framework, without attempting to use the hierarchical structures imposed by the control model. This results in a simple, reliable, and high quality estimation scheme.

Finally, completely decentralized estimation algorithms are being developed.

## ANALYZING THE IMPACTS OF TRANSPORTATION POLICIES ON RURAL MOBILITY AND ECONOMIC DEVELOPMENT

### PRINCIPAL INVESTIGATOR

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University of Minnesota  
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### AMOUNT

1979 — \$65,000  
(\$8,630 in university funds)  
1981 — \$58,880  
(\$8,580 in university funds)

### TENURE OF CONTRACT

September 1979 — November 1981

### MONITOR

Robert W. Crosby, DPB-25  
Research and Special Programs Administration  
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### ABSTRACT

If local communities are expected to increase their share in supporting rural transportation systems, they must be able to evaluate systems based on their contribution to rural mobility and community development. State and federal evaluation programs must be modified to reward transportation policies based not only on their short-term effects on system efficiency and productivity, but also on their long-term impacts on the rural economy. In order for public planners to promote such policies, they must first be able to identify and measure the impacts of these policies on rural mobility and development.

This project will review various indicators of mobility and economic development to be used for such purposes with special attention paid to measures which have sufficient available information and which can be used in rural areas.

Transportation policies that can influence such measures will then be determined. Case studies of rural systems in the Upper Midwest and empirical analysis of data from other areas will be used to help quantify this influence. A technique previously used to trace transit system performance across time will be extended to also describe mobility and economic and environmental conditions over time. Results from this research will be put in the form of a handbook to be used by transit managers and public officials in rural transportation system management and rural development planning.

### STATUS

Several tasks of the project have been completed. The literature review and assessment of relationships between transportation policies and rural mobility and economic development is finished. Also completed was the identification of rural indicators such as mobility, accessibility and economics. A system inventory of all rural transportation systems in the Upper Midwest was prepared, from which a suitable number of systems were selected for analysis.

The current research is concentrating on data collection from the selected case studies. In addition, work on the system analysis has begun. A dynamic model involving the labor market and economic growth was formulated. The model will be used to predict effects on unemployment, economic growth, and income resulting from changes in travel time, travel cost, and accessibility. A system of equations representing this model is also being developed.

### APPLICATIONS

The results of this research will be put in the form of a handbook which can be used by local and state policy makers in transit program management. The results have also been disseminated through various meetings and publications. Contact has been made with several potential users including the Area Transportation Authority of North Central Pennsylvania, Stagecoach Lines, and Minnesota Department of Transportation. Minnesota DOT has also contributed up to \$3000 time equivalent per project phase and has participated in the identification of transport policies of high priority to the state of Minnesota, data collection and evaluation of results.

## CITIZEN' PERCEPTIONS OF HIGHWAY IMPACTS

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1979 — \$69,470  
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### TENURE OF CONTRACT

June 1979 — August 1980

### MONITOR

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(617) 494-2071

### ABSTRACT

A knowledge of citizens' perceptions of highway impacts early in project planning and development is essential to successful and timely project completion. Based on the results of a content analysis of the public hearing transcripts, newspaper accounts, and planning documents of 40 highway projects in Iowa, Kansas, Missouri, and Nebraska, a comprehensive index to citizens' perceptions of highway impacts is being developed. The index will account for differences among interest groups, urban and rural areas, and techniques and procedures used to obtain citizen involvement. The research results will enable highway agencies to achieve more effective use of citizen participation in project planning and development.

### STATUS

The research on this project has been completed and a draft final report has been written.

The objective of this study was to investigate the predictability of citizen attitudes toward highway improvement projects based on the results of a content analysis of public hearing transcriptions. The study addressed the influences of several factors on citizen attitudes. Included among these factors were: (a) personal attributes of the citizens, (b) attributes of the improvement projects, (c) hearing atmosphere, (d) socioeconomic characteristics of the project area, and (e) project development procedures.

The measure of citizen attitude derived from the content analysis was a frustration index which reflected the intensity and persistence as well as the direction of feelings expressed in communication with state highway department officials. This index became the major dependent variable in the analysis, which tested the relative predictive value of established hypotheses relating to personal characteristics of involved citizens, distinct qualities of individual projects, characteristics of project settings, and specific procedures used in response to the action plans. The results of the study were a number of generalizable observations regarding citizen attitudes toward highway improvements in the four state area.

### APPLICATIONS

If impact statements are to be fully representative of concerns within the affected area and if project designs are to be reflective of the interests of the community as a whole, productive two-way dialogue must be generated among project designers and representatives of citizen interests, both broadly and narrowly defined. This project intended to contribute to such communication by: (1) facilitating an awareness of public perceptions of highway improvements and (2) evaluating the procedures currently employed by four neighboring states to invite citizen participation in the highway planning process.

Content analysis was tested as a means of monitoring the effectiveness of citizen participation techniques. Content analysis was found to generate a wealth of information with relatively little expenditure of time on each project. Once codebooks were developed and procedures established, the materials for a mid-level individual project could be coded in one day. The potential for monitoring the relative effectiveness of hearings was apparent. Even among the sample of projects reviewed for this study there was considerable variation in hearings—variation which cannot be reflected in a report simply stating attendance and summarizing the major points raised.

## COST-EFFECTIVENESS OF RETROFITTING CONCRETE MEDIAN BARRIERS

### PRINCIPAL INVESTIGATOR

Edward R. Post  
College of Engineering and Technology  
University of Nebraska, Lincoln  
226 Bancroft Hall, City Campus  
Lincoln, Nebraska 68588

### AMOUNT

1979 — \$76,455  
(\$17,828 in university funds)

### TENURE OF CONTRACT

August 1979 — October 1980

### MONITOR

Martin Oskard, HRS-12  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 557-5275

### ABSTRACT

Full-scale crash tests have demonstrated that concrete median barriers, such as the New Jersey design, are effective in safely redirecting compact and standard size automobiles under low angles of impact, 10 degrees and less. However, as impact angles increase above 10 degrees, the magnitude of automobile uplift, roll, and damage likewise increases. The objective of this research is to determine the cost-effectiveness of retrofitting existing concrete median barrier designs to suppress the vertical uplift and roll of different size automobiles. Suppression of vertical uplift and roll will reduce the severity of concrete median barrier impacts. A cost-effectiveness

analysis will be conducted to determine whether or not the reductions in accident costs associated with the lower impact severities would offset the cost of retrofitting. The retrofit unit will be designed so that it will not alter the performance of the original barrier for angles of impact of 10 degrees and less.

### STATUS

The first major task of this project has been completed. The objective of this task was to determine the potential cost-effectiveness of retrofitting New Jersey concrete median barriers in order to reduce accident severity, by suppressing the uplift and roll of automobiles striking the barriers at impact angles greater than 10 degrees. Cost limits of retrofitting were derived based on both a computer model simulation and an accident data analysis. The results of this study indicated that retrofitting New Jersey concrete median barriers would be cost-effective on freeways carrying traffic volumes greater than 40,000 to 60,000 vehicles per day. Also, it was found that the cost-effectiveness of such retrofitting would increase in the future, as the percentage of smaller vehicles in the traffic stream increases.

Future work on the project will consist of accident data analysis and conduct of full-scale crash tests. The purpose of these tests is to demonstrate improvements in impact performance.

### APPLICATIONS

The findings of this study will be useful for recommendations of retrofitting for various types of concrete median barriers. The results will help determine the best retrofit design for each of the different barriers in use. Once retrofitting is determined to be cost-effective, warrants would be established to retrofit barriers on the basis of traffic volume, speed, vehicle composition, and lateral offset distance. Also, new barrier designs could be constructed with the same shape as a retrofit unit.

## DEVELOPMENT OF IMPROVED ANALYTICAL TECHNIQUES FOR THE DESIGN OF THREE-PHASE TRACTION MOTORS

### PRINCIPAL INVESTIGATOR

Enrico Levi  
Department of Electrical Engineering  
Polytechnic Institute of New York  
333 Jay Street  
Brooklyn, New York 11201

### AMOUNT

1979 - \$125,727  
(\$6,617 in university funds)

### TENURE OF CONTRACT

June 1979 - May 1981

### MONITOR

Matt Guarino, RRD-21  
Federal Railroad Administration  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-9665

### ABSTRACT

The principal objectives of the research are a) to identify the limitations of existing three-phase motors and of the analytical techniques used in the prediction of their performance, and b) to develop a new and improved general approach to their design. This improved approach will allow the application of modern analytical and computational methods to a broad spectrum of three-phase traction motors, with special emphasis on new materials, optimum geometry for their intended use, and amenability to the analysis of new machines with unusual air-gaps and cross sections. Typical ex-

amples of unusual three-phase motors are the "tubular motor" being developed by British Rail for lightweight vehicles and the inductor rotary motor for lightweight vehicles, including electric buses and automobiles. The methodology is based on making the *air-gap field* of all machines (which is, generally, a complex two-dimensional region, due to slots and/or poles) the common foundation and starting point for all machine analyses. Modern techniques (including recent results from DOT's linear motor research) will be "synthesized." Sample designs will be carried out; the new method will be checked against laboratory tests on a "typical" motor.

### STATUS

Classification of motor types and pairing with applications have been completed. The research has involved survey and preliminary assessment of existing analytical methods used to predict the performance of the three-phase motors. In addition, the researcher has developed a number of computer programs and derived fundamental formulas. Currently, the research is focusing on obtaining all the necessary explicit formulas, then upon interpreting and integration of all the partial results into a comprehensive *direct approach* to the design, and finally, laboratory verification of this new direct approach.

The Phase I preliminary report entitled "Polyphase Traction Motors: a Direct Approach to the Design of New Machines" has been published.

### APPLICATIONS

The results of this research has been used to foster innovation in the design of three-phase traction motors; and to invent new machine topologies and geometries. Potential users include General Electric, Westinghouse, Garret AiResearch, and Reliance.

## DECENTRALIZED CONTROL OF STREET TRAFFIC

### PRINCIPAL INVESTIGATOR

Rudolph F. Drenick  
Department of Electrical Engineering  
Polytechnic Institute of New York  
333 Jay Street  
Brooklyn, New York 11201

### AMOUNT

1979 - \$44,500  
(\$4,049 in university funds)  
1980 - \$65,343  
(\$5,058 in university funds)

### TENURE OF CONTRACT

June 1979 - May 1981

### MONITOR

Diarmuid O'Mathuna, DTS-523  
U. S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2054

### ABSTRACT

This research explores certain new techniques for the control of traffic in city streets. Specifically, the objective of the project is the development and the preliminary assessment of the practicality of a theory leading to the design of decentralized control systems for traffic networks of city streets. The study will examine a promising parallel that exists between traffic

control on one hand and the efficient control and coordination in organizations in general on the other hand. This parallel seems to lead to insights and results in both, that have so far been inaccessible through existing theories. In particular, congestion avoidance and congestion relief through optimal traffic light management (perhaps supplemented with messages over public and CB radio channels) appear to be topics especially tractable by this approach, and their study is being undertaken.

### STATUS

The project is presently in the second phase of a three phase contract. In the first phase, a theoretical framework was developed, focusing on the analogy between the control of street traffic and organizational control and coordination process. A study of the achievability of minimax congestion control under various combinations of signaling options was also undertaken. Finally, street and traffic light coordination was studied.

The primary tasks of the second phase are the a) development of a novel algorithm for the solution of decentralized street traffic control and b) analysis of minimax control of competing directions of traffic flow.

### APPLICATIONS

While this research is basic, it is expected to lead to new ideas and new methods for the future control of traffic in city streets. The achievement of this objective is to be facilitated by a close cooperation with the Transportation Training and Research Center at Polytechnic Institute of New York. Contacts for future application of the research results have been established with members of the Federal Highway Administration.

## AN ASSESSMENT OF THE INTERSTATE HIGHWAY TRADE-IN PROCESS

### PRINCIPAL INVESTIGATOR

William H. Crowell  
School of Engineering  
Polytechnic Institute of New York  
333 Jay Street  
Brooklyn, New York 11201

### AMOUNT

1980 - \$44,992  
(\$4,094 in university funds)

### TENURE OF CONTRACT

September 1980 - August 1981

### MONITOR

Norman G. Paulhus, Jr., I-25  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-4208

### ABSTRACT

The Federal-Aid Highway Act and Highway Revenue Act of 1956 established the basis for the planning and construction of a 42,500 mile Interstate Highway System. While 90 percent of the system is complete, many of the urban portions of the original plan have been difficult to implement for a variety of social, economic, environmental, and political reasons. Provisions therefore have been added to the original act over the past 10 years to allow interstate links to be "traded in" for non-interstate highway and mass transit projects.

This project shall provide an overview of the Interstate highway trade-in process, and its association with other Federal transportation goals and programs. The research will consist of a thorough assessment of these important areas, including the merits of single- or multi-modal trust funds on the Federal level. In particular, this research will assess the legal aspects and implications of the Interstate trade-in process, including the resulting administrative policies. This area is a frequent source of confusion in the local debates, associated with various trade-in questions or options, and relatively modest yet thorough delineation of these issues should prove very useful.

## IMPACT OF TRANSPORTATION POLICY ON THE SPATIAL DISTRIBUTION OF RETAIL ACTIVITY

**PRINCIPAL INVESTIGATOR**

Clifford R. Kern  
 Department of Economics  
 State University of New York at Binghampton  
 Binghampton, New York 13901

**AMOUNT**

1979 - \$94,000  
 (\$10,483 in university funds)  
 1981 - \$96,513  
 (\$9,852 in university funds)

**TENURE OF CONTRACT**

June 1979 - August 1981

**MONITOR**

Jesse Jacobson, DTS-243  
 U. S. Department of Transportation  
 Transportation Systems Center  
 Kendall Square  
 Cambridge, MA 02142  
 (617) 494-2510

**ABSTRACT**

Many transportation policies that are directed towards the Central Business District (CBD)—parking restraints, parking surcharges, special toll or licensing arrangements, and auto-restricted zones—are likely to have important effects on the distribution of retail activity between the CBD and competitive shopping locations. Whether these retail impacts are explicit policy objectives or secondary consequences of policies to achieve other goals such as cleaner air, intelligent transportation planning requires that they be accurately understood. The objective of the research is to enhance such understanding by modelling four key components of the spatial distribution of retail activity: 1) shopping travel of individual households and its relationship to household characteristics, levels of transportation service, and a carefully specified list of shopping center attributes; 2) household retail expenditures, including both total annual expenditures and their distribution among alternative retail centers; 3) entry of new retail firms at alternative locations in response to changes in perceived profitability; and 4) decisions of existing retail stores to exit from the market. The model system can then be used to forecast policy impacts.

**STATUS**

Phase I of the study has been devoted to model specification and estimation. Results achieved during this phase relate

entirely to methodological issues rather than substantive policy implications. Specific research products of Phase I include models of home-based shopping travel, consumer expenditures, and retail store location: a) joint disaggregate models of mode and destination choice have been estimated for home-based shopping at major regional shopping centers; b) a model of consumer expenditure has been adapted from the consumer demand literature to convert forecasts of shopping trip distribution into forecasts of retail sales at alternative shopping destinations; and c) multimodal logit model of competition by stores for retail floorspace has been developed and estimated.

In the second phase, after the forecasts from the model system have been validated against actual data on the spatial distribution of retail activity, both individual components of the model system and, to the extent possible, the fully integrated model system will be used to forecast the impact of various transportation policies on retail activity in the CBD and competing suburban centers. The policies to be examined include establishment of a downtown auto-restricted zone, creation of a downtown shopping mall with amenities similar to those at suburban centers, improved transit service to and within the CBD, free transit service, restrictions on downtown parking, and downtown parking and access surcharges. Policies will be simulated alone and in combination.

**APPLICATIONS**

A partial list of potential users of this study would include:

- Federal officials choosing among transit capital grant applications, where such applications argue that the proposed capital would help improve the downtown core;
- Local officials, attempting to select among various parking management, auto restriction, or capital investment strategies;
- Air quality agencies attempting to assess the influence of alternate transportation control plans on the urban core;
- Urban redevelopment agencies attempting to design new, vital retail areas;
- The private developer desiring projections of potential retail sales in various areas;
- Metropolitan planning organizations concerned with the spatial redistribution of retail activity in a metropolitan areas that might be induced by alternate investment programs; and
- Federal policy-makers concerned with approaches to increasing or preserving the viability of urban core areas.

## A THEORY FOR TRACK MAINTENANCE LIFE PREDICTION

### PRINCIPAL INVESTIGATOR

Ernest T. Selig  
Department of Civil Engineering  
State University of New York at Buffalo  
Parker Engineering Building  
Buffalo, New York 14214

### AMOUNT

1977 - \$80,000  
(\$13,502 in university funds)  
1978 - \$75,000  
(\$14,040 in university funds)  
1980 - \$1,752

### TENURE OF CONTRACT

July 1977 - August 1980

### MONITOR

Phillip Mattson, DTS-741  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2431

### ABSTRACT

Over a period of time, railroad track will settle as a result of permanent deformation in the ballast and underlying soil layers produced by traffic loading. After some period of time, maintenance will be needed to resurface and line the track. Suitable methods do not presently exist for predicting the maintenance life, which is a function of many factors. This study develops a theory for prediction of track settlement which is applicable to estimating maintenance life for new or existing track. The research approach focusing on the inelastic behavior of soil, involves: 1) establishing required characteristics for the track system components, 2) setting up a computer model, 3) studying the behavior of ballast and soil under representative cyclic loading, and 4) validating the model using available field experience, including data from the Facility for Accelerated Service Testing (FAST) in Pueblo, Colorado.

### STATUS

The project is completed.

### APPLICATIONS

This research will be valuable in improved railroad track maintenance life prediction.

## ECONOMIES OF SCALE IN THE U.S. INTERCITY BUS INDUSTRY

### PRINCIPAL INVESTIGATOR

Gorman Gilbert  
Department of City and Regional Planning  
University of North Carolina  
Chapel Hill, North Carolina 27514

### AMOUNT

1979 - \$33,782  
(\$1,601 in university funds)

### TENURE OF CONTRACT

May 1979 - June 1980

### MONITOR

Karen Borlaug, P-54  
Office of Transportation Regulation  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-4420

### ABSTRACT

The intercity bus industry is presently experiencing financial difficulties in terms of declining ridership and greater-than-inflation increases in costs. The financial difficulties of the bus industry present special problems for consumers in smaller cities and rural areas dependent on the bus. As financial difficulties persist, light-density routes are likely to be those that are first eliminated as these routes are often reviewed as unprofitable. Attempts to find alternative solutions to this problem are impeded by a considerable lack of information regarding the structure of the bus industry. The industry

has been regulated as if it were a natural monopoly possessing inherent economies of scale. However, there is no empirical evidence to support this assumption, and it then becomes difficult to assess federal policy proposals. This research project will provide the needed information on the industry.

Data on Class II and III carriers will be collected from Interstate Commerce Commission (ICC) public files to provide information comparable to that available from the ICC Statement 750 for Class I firms. These will include cost and revenue data for the industry and operating statistics. Efforts will be made to obtain the data for a number of annual reporting periods to allow both cross-sectional and time-series analysis. Econometric methods will then be used to analyze the data and test hypothesis that economies of scale exist in the intercity bus industry.

### STATUS

All of the research on this project has been completed, and the final report is in preparation. After compiling a survey of literature relevant to intercity buses, the research centered on hypothesis generation. After finalizing the hypothesis, the sample of Class II & III carriers was drawn. ICC files revealed data for over 600 Class II & III forms. The model development included a review of available mathematical forms used for cost functions; a trans log model was selected, which allowed inferences to be made, from the coefficients, of the significance of specific factors such as fuel costs.

### APPLICATIONS

The research is being used by various agencies concerned with intercity buses. For example, the ICC has considered open entry requests which utilize similar research findings. Other potential users include DOT, industry personnel, and North Carolina utilities officials.

## EVALUATING RURAL PUBLIC TRANSPORTATION DEMONSTRATIONS

### PRINCIPAL INVESTIGATOR

Joyce Johnson  
Transportation Institute  
North Carolina A&T State University  
Greensboro, NC 27411

### AMOUNT

1975 - \$73,349  
(\$4,409 in matching funds from North Carolina A&T;  
\$6,000 from cooperators)  
1977 - \$69,600  
(\$6,408 in matching funds from North Carolina A&T;  
\$3,000 from cooperators)  
1978 - \$70,000  
(\$5,746 in matching funds)

### TENURE OF CONTRACT

November 1975 - July 1979

### MONITOR

Robert H. Bruton, P-33  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-4435

### ABSTRACT

This study is designed to contribute to the evaluation of rural public transportation demonstrations, funded under Section 147 of the 1973 Federal Aid Highway Act. Subsequently, recommendations will be made for the development of policies for rural public transportation.

The first phase of the research reviewed and developed evaluation measures and methodologies to determine system performance, impacts on riders and the community, inter-agency cooperation and the system's future viability. A major effort was made to coordinate this research with the evaluation efforts of the Federal Highway Administration. During the second phase the research team will collect and analyze data on

1) the planning process; low cost alternatives for increasing ridership or decreasing costs and identification of non-users for two sites. The research team will also prepare case studies, identify national rural transportation policy questions, and assist five sites with their collection of baseline data and on-board surveys.

The results of the study will be useful to the transportation operators and planners, as well as to government officials, in determining the potential and problems of rural public transportation and the resolution of several questions of policy.

### STATUS

Several documents resulted from the first phase—among them were: 1) individual planning and operation case studies of the four sites visited and monitored, 2) summation of low-cost alternatives for rural transportation operations, and 3) summation of marketing and promotion techniques of the systems studies. A major document prepared by the research team was the proceedings from the First National Conference on Rural Public Transportation.

Other project results include:

1. Compilation of a list of names of more than four hundred planners, managers, state DOT persons, consultants, vehicle suppliers, and others interested or involved with rural transportation was compiled and computerized.
2. Review of many draft and unpublished reports from the U.S. DOT, state agencies, and local systems, in addition to the published articles on rural transportation and evaluation and a written summary of the evaluation measures and methods.
3. Development of a conceptual model of a rural transportation system. The model's major components include the initial conditions, output, constraints, and impacts of a rural transportation system.

Future research tasks have been revised to explicitly complement the data collection and evaluation efforts of FHWA. Future research emphasizes understanding the planning process, identifying low cost alternatives to reduce costs or increase ridership.

## AN EMPIRICAL TEST OF THE UTILITY OF ATTITUDINAL MEASURES FOR SHORT TERM PUBLIC TRANSPORTATION PLANNING

### PRINCIPAL INVESTIGATOR

Lalita Sen  
Department of Sociology  
North Carolina A&T State University  
Merrick Hall  
Greensboro, North Carolina 27411

### AMOUNT

1979 - \$71,000  
(\$13,037 in university funds)  
1980 - \$70,000  
(\$2,200 in university funds)

### TENURE OF CONTRACT

September 1979 - October 1980

### MONITOR

Mark Stahr HHP-22  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-0182

### ABSTRACT

This research will investigate the usefulness of a variety of psychological measurement techniques for transportation planning and forecasting. Using existing data, the techniques will be tested for consistency by obtaining responses for all approaches from the same subjects. Stated and revealed preferences will be compared in a before and after design in conjunction with transit demonstration project.

The objectives of the research are 1) to test various disaggregate models incorporating attitudinal and behavioral measures on communities with varying geographic and demographic conditions; 2) to determine which model(s) may be most appropriate for each type of community; 3) to deter-

mine the utility of such models for evaluation of public transportation policy or systems changes, such as different types and pricing of public transportation services; and 4) to test the validity and consistency of a variety of psychological measurement approaches.

### STATUS

The data to be used for the evaluation of the five disaggregate modeling approaches has been collected. These user responses were obtained from two sources. One was selected from existing behavioral and attitudinal data sets from a large metropolitan area with a number of transportation service options. The other data set was a small sample collected from a small community with more limited transportation service options. This data is now being processed for preliminary analysis. A technical manual is being written.

### APPLICATIONS

The results of this research are expected to be used by transit planners at the test site and by various state and local transit planners in the state of North Carolina. The results should also be useful to other researchers both academic and non-academic who are interested in the use of attitudinal measures as an aid in transportation planning.

The Planning and Marketing Directors of the Charlotte Transit Authority have been extremely helpful in providing background information as well as physical facilities to facilitate the collection of relevant data and information. While the University has incurred the total cost of collecting the data and information during the first phase, the North Carolina Department of Transportation, Mass Transit Division, is interested in contributing towards the cost of collecting the required data/information for the second phase.

Contact has also been made with several potential users such as the New York DOT, Planning and Research Division; Transportation Research Board; New Jersey DOT; UMTA; and numerous universities.

## THE EQUITY AND ADEQUACY OF TRANSPORTATION FACILITIES IN BLACK COMMUNITIES: THE PROBLEM OF RESIDENCE—SHOPPING PLACE SEPARATION

### PRINCIPAL INVESTIGATOR

Woodrow W. Nichols, Jr.  
Department of Geography  
North Carolina State University  
1801 Fayetteville Street  
Durham, North Carolina 27702

### AMOUNT

1979 - \$50,000  
(\$4,901 in university funds, \$5,000 cooperator share)

### TENURE OF CONTRACT

June 1979 - August 1980

### MONITOR

Patrick Little, DTS-23  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2071

### ABSTRACT

The objective of the research is to examine the relationship between residential segregation, the decentralization of retail and commercial activities, and the suitability of transportation systems for shopping travel in three black communities. The research, which has been performed using presently available data and existing models, documents residential segregation of Black Americans and changes in commercial land use, examines the influence of retail location on shopping travel, and determines the adequacy of present transit systems with regard to the service needs of subgroups among the black residents.

### STATUS

Five of seven chapters for the final report have been completed. The work described in the completed chapters consist of the following: Chapter 2 discusses the major concepts of the investigation—residential segregation, retail decentralization, and metropolitan transit systems. Chapter 3 reviews and discusses major theories, models, and the problems associated with understanding black consumer travel behavior. Chapter 4 constructs Gini indices and Lorenz curves for the selected study areas in order to provide a measure of racial residential segregation. Using geostatistical techniques, it also measures the extent to which retail establishments have changed locations over time in the study areas. Chapter 5 seeks to determine the extent to which retail location influences the shopping travel behavior of households in black segregated, white segregated, and nonsegregated communities within the study areas. Chapter 6 will determine the adequacy of transit service for urban black residents' shopping trips. The final chapter will examine the strengths and weaknesses of current policy and propose recommendations for future policy.

### APPLICATIONS

This research will be useful to transportation planners as an aid to transportation facilities planning, particularly if the intent is to prevent unequal impact of transit facilities upon certain population groups. The metropolitan areas of Baltimore, Milwaukee, and Minneapolis-St. Paul constitute the study areas; however, other areas should be able to utilize the results also. The planning commissions of the respective study areas have been informed of the study.

The Institute for Transportation Research and Education is a cooperator on this project.

**UNIVERSITY OF N. FLORIDA & EDWARD WATERS COLLEGE CONTRACT NO: DT-RS-58-80C-00023**

**MINORITY PARTICIPATION IN THE REGULATED  
MOTOR CARRIER INDUSTRY**

**PRINCIPAL INVESTIGATOR**

Jay A. Smith, Jr.  
College of Business Administration  
University of North Florida  
P.O. Box 17074  
Jacksonville, Florida 32216

**AMOUNT**

1980 - \$111,000  
(\$21,894 in university funds)

**TENURE OF CONTRACT**

August 1980 - October 1981

**MONITOR**

Karen Borlaug, P-54  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D. C. 20590  
(202) 426-4420

**ABSTRACT**

The current and future prospects of minority participation in the trucking industry are closely related to the

regulatory policies of the industry. The benefits of relatively low capital investment in trucking which would permit easy entry are mostly negated by regulatory actions. These regulatory procedures have made it especially difficult for economically disadvantaged persons and minority firms to obtain Interstate Commerce Commission (ICC) certificates.

Employment of minorities within the trucking industry has suffered for several reasons, including perception of opportunities for minorities, lack of meaningful manpower utilization by motor carriers, and management development programs which have not offered equal opportunity.

The objective of this research is to identify, describe, document, and quantify the problems of minority participation in trucking, and to evaluate alternative policy solutions which may be used by government agencies, industry trade associations, and/or individual carriers to improve minority involvement.

This program of research will be conducted through two phases: Phase One includes data collection and analysis; Phase Two will include the a) development of a minority employment profile as well as a survival profile and b) development and evaluation of alternative regulatory policies. The final report will contain a complete profile of the minorities and economically disadvantaged in the regulated motor carrier industry and possible solutions to increase minority participation.

## DEVELOPMENT OF HYBRID FUNCTIONS FROM ENGINEERING AND STATISTICAL TECHNIQUES: THE CASE OF RAIL

### PRINCIPAL INVESTIGATOR

Andrew Daughety  
Transportation Center  
Northwestern University  
Evanston, Illinois 60201

### AMOUNT

1977 - \$57,996  
(\$3,409 in university funds)  
1979 - \$66,000  
(\$4,623 in university funds)

### TENURE OF CONTRACT

September 1977 - October 1980

### MONITOR

Joel Palley, RPD-32  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
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(202) 426-9682

### ABSTRACT

Meaningful public policy analysis in the transportation industries requires empirical understanding of costs. This is particularly true in regulatory proceedings regarding questions of rates, and in determination of subsidies for providing specific services which are uneconomic but deemed socially desirable. A concept of special significance in this regard is the so-called "incremental cost" of providing such services.

### STATUS

Research in the first phase provided the basic techniques for

using a hybrid engineering/statistical approach to estimate cost functions involving service characteristics and quantity flows. The estimated model was used to compute cost elasticities, factor demands and marginal costs for different commodity groupings and was tested on a small railroad.

During the second phase, the analysis was extended to a major rail system, incorporating network, commodity-type and multiple-service-characteristic complexities. The cost model is a multi-output, multi-input price transcendental logarithmic model with terms representing quality of the system track, i.e., it is a short-run variable cost model, which incorporates engineering process functions for linehaul train movement and yard activities. Speed is viewed as a stochastic output and the models are used to provide expected time in the system.

The final work included testing the engineering models with collected data, and expanding the work on the cost modelling side by focusing on aggregation issues. Specific attention was paid to using the technique to determine incremental costs which would provide valuable analytic assistance in implementing the concepts embodied in existing and proposed legislation for modifying the regulatory process.

### APPLICATIONS

The research will have several immediate practical implications. It is the first time that data which is readily available and generally collected by rail industries has been shown to be useful to the determination of cost functions using standard economic theory. This will allow RR managerial staff to develop a theoretically sound idea of the actual costs of service delivery. The method developed has significant advantages over traditional economic and traditional engineering cost indices; in particular it is a more accurate reflection of non-engineering costs (legal, marketing, etc.) than traditional engineering cost estimates, yet reflects the nature of the production of services more accurately than traditional economic estimations.

## THE EFFECTS OF TRANSPORTATION ON THE TAX BASE AND DEVELOPMENT OF CITIES

### PRINCIPAL INVESTIGATOR

Alex Anas  
Department of Civil Engineering  
Northwestern University  
Evanston, Illinois 60201

### AMOUNT

1979 - \$77,205  
(\$4,095 in university funds)  
1981 - \$71,250  
(\$3,750 in university funds)

### TENURE OF CONTRACT

July 1979 - December 1981

### MONITOR

Robert Martin, DPA-32  
Research and Special Programs Administration  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4502

### ABSTRACT

This research is focusing on the parallel development and comparative evaluation of two sets of methods aimed at analyzing and predicting the effects of transportation characteristics and transportation systems on the property values and the tax base of metropolitan areas. The Chicago metropolitan areas is used as a case study.

The first set of methods centers on the application of linear regression analysis to estimate the impacts of transportation characteristics at a micro level using a data base which contains detailed information on the sale prices and building characteristics of the tax parcels within the city of Chicago. These methods are intended for analysis and forecasting of transportation effects on a small area basis.

The second set of methods centers on the application of multinomial logit models to produce equilibrium analyses and forecasts of the impacts of transportation characteristics at a small area aggregation level. The data set used for these

methods is not limited to the city of Chicago but covers the entire metropolitan area. These methods enable the multimodal analysis and forecasting of transportation effects on a metropolitan wide basis with primary focus on commuting travel and its impact on residential property values and tax rates.

### STATUS

The work being done can be grouped into two categories. One of these is the application of linear regression analysis to urban real estate data for the purpose of estimating and forecasting the impact of transportation characteristics on property values and the tax base in the city of Chicago.

Another part of the work deals with the application of multinomial logit demand estimation methods to forecasting the impact of transportation characteristics on city property values and tax bases. Results have been obtained both in the estimation of and forecasting with multinomial logit models.

Work on the application of linear regression analysis with particular emphasis on the detailed study of five specific transportation corridors in the city of Chicago is continuing. Work on the application of logit models is intended to proceed to the forecasting stage and will focus on the development of a computer based procedure to implement the forecasting method.

### APPLICATIONS

The recommended method(s) which will emerge out of this research can be applied by metropolitan planning organizations as part of their transportation alternatives analysis programs, to gain insights and to develop specific evaluations of the impacts of proposed alternatives on property values and the tax base.

There has been communication with the Chicago Area Transportation study, which is an agency of the State of Illinois, and the Bureau of Transportation Planning and Programming of the Department of Public Works of the City of Chicago. These agencies are in a position to apply the methods that are being developed. The staffs of the Chicago Area Transportation Study and Department of Public Works were generous in supplying or helping to obtain the data used in this research.

## IDENTIFICATION OF CONDITIONS FOR EFFECTIVE TRANSFERABILITY OF DISAGGREGATE CHOICE MODELS

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1980 - \$68,345  
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### TENURE OF CONTRACT

June 1980 - September 1981

### MONITOR

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### ABSTRACT

Disaggregate models of travel choice behavior have been ex-

tensively developed during the last decade. These models have been applied to forecast the travel impact of transportation alternatives in a small number of transportation contexts. It is generally argued that disaggregate choice models developed in one geographic environment can be transferred to other environments. Effective transferability of these models is essential to their use in forecasting in the area of model development or in other areas. However, the transferability of choice models has not been successfully demonstrated. Consequently, the primary assumptions which underlie transferability (stability of the choice process and full representation of the choice process in the choice model) require empirical evaluation.

This research will evaluate the transferability of a set of alternative disaggregate choice models to determine those conditions under which model transferability is effective. Phase I of the research will develop a conceptual structure to evaluate transferability, develop measures of transferability, and determine the characteristics of model specification and context which influence transferability. Phase II of the research will identify refinements in specification needed to enhance the transferability of selected models based on their relative contribution to model transferability.

## A COMBINED EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF THE INFLUENCE OF LOW LEVEL AND SHEAR ON THE HANDLING CHARACTERISTICS OF AIRCRAFT

### PRINCIPAL INVESTIGATOR

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College of Engineering  
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### AMOUNT

1978 - \$30,275  
(\$1,593 in university funds)  
1979 - \$35,282  
(\$1,857 in university funds)

### TENURE OF CONTRACT

June 1978 - July 1980

### MONITOR

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(202) 426-8605

### ABSTRACT

This research is a two year analytical and experimental investigation of the influence of low level wind shear on aircraft handling characteristics. Wind shear is a spatial change in wind speed and/or direction. When an aircraft encounters a wind shear on final approach, or during take-off, the wind shear can have a tendency to disturb the aircraft's equilibrium. Cur-

rent aerodynamic data consists primarily of wind shear analyses devoted to air carrier type aircraft, which are conventional take-off and landing (CTOL).

This research addresses the problem of short take-off and landing (STOL) aircraft. In order to perform an analysis of an STOL aircraft encountering wind shear, it is necessary to understand the change in aerodynamic derivatives of typical STOL airfoils due to wind shear by performing wind tunnel tests and checking the results against standard mathematical analysis.

### STATUS

The first phase work consisted of a) developing the environment for performing a complete dynamic stability test and analysis of airfoils encountering a wind shear, and b) force and moment wind tunnel tests. Results of the first year's work included the design and fabrication of five wind tunnel models used for force and moment tests. The results of these tests indicated that wind shear will degrade the longitudinal aircraft characteristics.

The second phase involves the dynamic testing and analysis of wing models encountering wind shear, and a new analysis of the effect of wind shear on STOL aircraft, using the data from the wind tunnel tests.

### APPLICATIONS

The results of this research should provide definitive answers to the possible hazards that an STOL aircraft might encounter due to wind shear. Specifically, these results are being used by the Federal Aviation Administration and the National Aeronautics and Space Administration to study wind shear problems of commuter aircraft.

## ENVIRONMENTAL PROTECTION DURING AND FOLLOWING TRANSPORTATION ACCIDENTS/EMERGENCIES

### PRINCIPAL INVESTIGATOR

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Science  
University of Oklahoma  
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### AMOUNT

1979 - \$69,889  
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### TENURE OF CONTRACT

June 1979 - January 1981

### MONITOR

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### ABSTRACT

The objective of this research is to prepare a state-of-the-art document which describes current and potential environmental protection measures for hazardous material releases from transportation accidents/emergencies. The document will be written for use by practitioners in the field. Emphasis on pro-

tected measures will be given to short-term, emergency water treatment measures; development of nomographic charts for predicting short-term air pollutant dispersion and resultant human evacuation needs; long-term measures to minimize on-site soil and vegetation contamination and runoff water contamination; and proper disposal of contaminated materials containers.

### STATUS

An extensive literature review has been completed, as well as a survey of pertinent Federal and State regulations and implementation plans for transportation of hazardous materials. A review of Utilized Environmental Protection measures has begun, which included a visit to the National Transportation Safety Board in Washington to review their accident and emergencies records. Finally, selection criteria which include type of accident, magnitude of accident, geographical location, and potential environmental contamination, have been identified for the case studies.

### APPLICATIONS

The final report on this project will be organized as a technology transfer document for persons working on environmental protection measures applicable to transportation accidents/emergencies involving release of hazardous materials. The project report could be provided to professionals in the field to form the basis for short course training activities.

## AN EXAMINATION OF THE UNREGULATED TRUCKING EXPERIENCE IN DELAWARE

### PRINCIPAL INVESTIGATOR

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University of Pennsylvania  
3718 Locust Walk  
Philadelphia, Pennsylvania 19104

### AMOUNT

1978 - \$23,733  
(\$7,613 in university funds)

### TENURE OF CONTRACT

July 1978 - January 1980

### MONITOR

Karen L. Borlaug, P-54  
Laurence T. Phillips, P-54  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4420

### ABSTRACT

The objective of the research is to present a detailed case study of the performance of the unregulated intrastate motor carrier industry in Delaware. The current system is completely free of entry-exit, rate, and level of service regulations. The research shall document the rates charged and the level of service rendered to Delaware shippers for both intra-Delaware shipments and for comparable regulated interstate shipments. The characteristics of the trucking participants in Delaware shall be collected and compared to the industry in general with respect to such items as entry-exit experience, concentration and bankruptcy.

Data from the Delaware Division of Motor Vehicles, the Middle Atlantic Rate Conference, and other sources shall be gathered, analyzed, and conclusions regarding the Delaware experience drawn. Policy lessons and recommendations growing out of the Delaware experience shall be the end product of the research.

### STATUS

Final report has been submitted.

### SUMMARY

Because of the dominance of one of the three counties in the state (New Castle) and its main urban center (Wilmington), most of the motor carrier transportation in Delaware is very short distance in nature. The analysis shows that very little interstate Delaware freight exists. Because of its small magnitude and short distance nature, such traffic is generally hauled by private carriage. In the small number of cases where intrastate Delaware movements were taking place, rates were less than or equal to comparable (commodity, weight, distance) regulated moves. In most instances rates were stated as equal to comparable regulated rates. In no cases were intrastate Delaware rates reported as higher. Intrastate service levels were greater than or equal to interstate service levels. Here, too, most often the response was that the service was the same. Overall it appears that because such a small amount of movement occurs within the state, that no regulatory pressure has appeared in recent time.

### APPLICATIONS

This research will be useful to policymakers in the discussions and decision-making over regulatory reform. This is a follow-up to Dr. Allen's recent study of trucking experience in New Jersey. Interest in the current study has come from numerous state agencies, such as the Georgia Department of Audits, Florida Public Utilities Commission, California and Pennsylvania Legislative Offices, Maine Attorney General, Michigan Public Service Commission, and other state officials in New York, New Jersey, Kansas, South Dakota, Wisconsin and Oregon. Dr. Allen presented the study in written testimony in a state antitrust case—the State vs. the New Jersey Tank Truck Carriers. Dr. Allen also presented a preliminary summary of the results of the Delaware study to the Sunset Committee on Surface Transportation Regulation of the State of South Dakota in June of 1979. In addition, he presented a workshop paper at the TRB's Conference on State Transportation Planning in May 1979. The results are expected to be widely used by states investigating regulatory reform in the motor carrier area.

## A CASE STUDY OF THE 1977 EXPANSION OF THE PHILADELPHIA COMMERCIAL ZONE

### PRINCIPAL INVESTIGATOR

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University of Pennsylvania  
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Philadelphia, Pennsylvania 19104

### AMOUNT

1978 - \$36,977  
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### TENURE OF CONTRACT

July 1978 - January 1980

### MONITOR

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### ABSTRACT

Shipments which both originate and terminate in a commercial zone are exempt from Interstate Commerce Commission (ICC) regulation (Section 203 (b)(8) of the Motor Carrier Act of 1935). This research investigates the cost and service levels afforded to shippers/receivers within the Zone as opposed to the cost and service available to comparable shipments outside the Zone.

The impact of the recent sizable expansion of the Philadelphia Zone has been examined in an exhaustive case study, with emphasis on the experiences of participating carriers, e.g., entry, exit, profitability. The study examined the impact of the zonal expansion on shipping patterns, land use, energy consumption, and the environment.

### STATUS

All research is completed; a draft final report was submitted in May 1980.

### SUMMARY

In general the preliminary results show that the Philadelphia expansion yielded results not unlike those found in a GAO study released in 1978. Most shippers/receivers report that no major changes have occurred. The shippers/receivers reporting impacts virtually always report favorable results. In general service levels have improved for long haul shipping as the results of direct service as opposed to interlining. Not all interlining has been done away with however. Rate savings are small (on the order of 5%) with most respondents reporting no changes in rates.

A reputed influx of so-called "gypsy haulers" could not be empirically substantiated. Clearly new entry did occur. Exit of carriers was only secondarily attributed to the expansion of the zone. A number of carriers were benefitted by the expansion (primarily long haul carriers) but some short haul carriers also found it a way to expand business.

### APPLICATIONS

This research will prove valuable to policymakers concerned with regulatory reform of the motor carrier industry. A number of state agencies concerned with trucking deregulation have shown interest in this study, for example, the Wisconsin Department of Transportation. University faculty undertaking studies of truck regulation for the Colorado Attorney General and an Arizona State senator have sought the study results. Preliminary results were reported in a seminar in June 1979 to a committee of the South Dakota Legislature. The results of this study, along with Dr. Allen's projects on unregulated trucking in New Jersey and Delaware were used in written testimony in a New Jersey antitrust case involving the New Jersey tank truck carriers. Numerous state legislative and attorney general offices have utilized the results in addition to several Public Utility Commission offices across the nation.

## DEVELOPMENT, TESTING AND APPLICATIONS OF TRANSPORTATION SUPPLY MODELS

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1979 - \$68,988  
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### TENURE OF CONTRACT

July 1979 - August 1980

### MONITOR

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Washington, D.C. 20590  
(202) 426-0182

### ABSTRACT

The objective of this research is (1) to improve the quality and usefulness of transportation supply models used in transportation planning, and (2) to improve our understanding of

how these models should be used. This research focuses on supply models for various modes of public transportation, partly because these are among the weakest models in urban transportation planning, while at the same time planning for transit is an increasingly large aspect of planning efforts. A better understanding of supply behavior of transit management will help considerably in deciding such important issues as the proper form and amount of transit operating subsidies, and the best forms of regulation of transit. The research consists of testing and refining existing supply models, which deal primarily with travel time aspects of level of service.

### STATUS

Development, testing, and checks for transferability of supply models for conventional bus and rail systems has been completed. The researcher is currently in the process of completing the taxonomy of supply models; also, models are being used to evaluate transit service and to check for discriminatory service policies.

### APPLICATIONS

The supply models can be used to predict flows, evaluate transit improvements, evaluate service, and predict future costs.

## THE AUGMENTATION OF FREIGHT TRANSPORTATION DATA SETS

### PRINCIPAL INVESTIGATOR

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University of Pennsylvania  
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Philadelphia, Pennsylvania 19104

### AMOUNT

1980 - \$43,486  
(\$14,937 in university funds)

### TENURE OF CONTRACT

August 1980 - June 1981

### MONITOR

Donald G. Wright, DTS-231  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
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### ABSTRACT

A wide spectrum of freight transportation data exists today. However, these are collected by various government agencies for differing reasons and lack consistency with respect to

spatial, temporal, modal, and commodity coverage. No data set currently collected approaches being comprehensive in nature. In addition, data collection is expensive and time consuming.

The purpose of this research is to explore techniques of developing complete commodity flow estimates, at some useful level of geographic and industry detail, by incorporating the available freight transportation statistics together with non-transportation economic data into an internally consistent accounting framework. Data sets to be evaluated for freight movement data augmentation will include (but are not restricted to) Bureau of Census' County Business Patterns, Census of Manufacturers, Census of Wholesale Trade, Census of Retail Trade, Annual Survey of Manufacturer's various commodity flow surveys and various national and regional input/output models. The research shall comprise a 12-month effort and result in a final report documenting: a) a review of feasible approaches to transportation data augmentation, 2) elaboration and justification of a preferred methodology, and 3) demonstration of the augmentation approach applied to selected data sets, to the extent possible within project resources. The products of the research shall include sample augmented commodity flow data sets which can be generated from existing data, the testing of such data sets against actual data, evaluation of the sensitivity of such sets to the assumptions made, and estimation of the benefits and costs of having such data.

## FINGERPRINTING VERSUS FIELD PERFORMANCE OF PAVING GRADE ASPHALTS

### PRINCIPAL INVESTIGATOR

David Anderson  
Department of Civil Engineering  
The Pennsylvania State University  
212 Sackett Building  
University Park, Pennsylvania 16802

### AMOUNT

1978 - \$50,490  
(\$2,657 in university funds)  
1979 - \$56,943  
(\$2,997 in university funds)

### TENURE OF CONTRACT

July 1978-November 1980

### MONITOR

Joseph Zenewitz, HRS-23  
Federal Highway Administration  
Fairbank Highway Research Station  
McLean, Virginia 22101  
(703) 557-5204

### ABSTRACT

In the past few years there have been a number of failures of asphaltic concrete pavements that are increasingly attributed to changes in the composition of the asphalt. Since the energy crisis and the oil embargo of 1973, petroleum crude has been in short supply, affecting refinery operations and causing suspicion relative to the composition and uniformity of the asphalt cement. As opposed to specification by chemical composition, asphalt is specified by physical properties which cannot, in themselves, pinpoint changes in composition. Fractional composition techniques that can pinpoint composition are available and, further, these techniques have been correlated with performance. In this research, the Rostler fractional composition techniques that can pinpoint composition are available and, further, these techniques have been correlated with performance. In this research, the Rostler fractional com-

to field performance to answer the question of whether or not there have been changes in asphalt quality.

### STATUS

Phase I of the project is finished, and the results obtained are being incorporated into the Phase II study. The objective of the Phase II study is to chemically and physically characterize a wide spectrum of paving asphalts sampled from refineries, new construction, and inservice pavements. Data from the characterization will be compared with the Phase I results, data in the FHWA data bank, and data from other sources to determine if physical or chemical characterization can be associated with performance.

That Phase II study is essentially an expansion and refinement of the Phase I study. A minimum of 50 additional asphalt samples will be evaluated in the Phase II study. Testing procedures used in the Phase I study will include physical testing (viscosity, penetration, softening point, etc.), fractional composition (Rostler), and tests on compacted mixtures (Marshall, modulus testing, stripping, etc.). As appropriate, synthetic asphalts from recombining fractions, blending, or addition of additives will be studied. Additional work on this contract is being funded by the Federal Highway Administration (FHWA).

### APPLICATIONS

The results of the research will be in a format that can be readily disseminated and implemented through regular FHWA channels to the appropriate state agencies and engineers. Further implementation will be effected by interacting with the various state agencies that provided samples for testing, and by participation on the appropriate committees of the American Society for Testing and Materials (ASTM) and the Transportation Research Board (TRB).

The results are currently being used by the Federal Highway Administration. Recommendations will be made for upgrading problem asphalts, either through specification changes or changes in construction practice. The results will also be useful to State DOT's and to contractors involved in the construction and maintenance of roads using asphalt.

## SOFTWARE RELIABILITY IN AIR TRAFFIC CONTROL SYSTEMS

### PRINCIPAL INVESTIGATOR

Bharat Bhargava  
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University of Pittsburgh  
319 Alumni Hall  
Pittsburgh, Pennsylvania 15260

### AMOUNT

1979 - \$47,000  
(\$3,516 in university funds)

### TENURE OF CONTRACT

September 1979 - August 1980

### MONITOR

David F. Clapp, DTS-523  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2050

### ABSTRACT

The objective of this research is to investigate, enhance, implement and validate techniques that will make the automated air traffic control system reliable without compromising on efficiency and economy. The algorithms developed will be suitable for a real-time processing environment and will facilitate the monitoring of system reliability. In case of system problems, failures will be detected, diagnosed and possibly

corrected (or bypassed by employing alternative software) to allow continuity of system operation by gracefully degrading to a lower level of efficiency and capacity. It will be possible to monitor the degradation levels so that appropriate warnings or signals can be given to a human controller who can perform some selected tasks to control further spread of errors and/or improve system efficiency.

### STATUS

The majority of the work on this project has been completed. A study of the architecture of enroute Air Traffic Control Software and its characteristics was the initial task, and this has been finished. Also completed was a survey of error detection, error correction, and error by-pass techniques.

The research concluded with a cost/reliability analysis of recovery block scheme and a simulation study to determine implementation and performance in enroute Air Traffic Control Systems. The simulation measured the following parameters: a) reliability (in terms of number of failures), b) cost (in terms of execution time of software modules, and c) Cost - Reliability Index. Several reports on this research have already been published and the Final Report is in preparation.

### APPLICATIONS

The methodology and techniques developed in the research may be used in the software implementation of enroute Air Traffic Control Systems so as to increase its reliability in daily operations. The contractor has already been in communication with the Cleveland Enroute Air Traffic Control Center.

## SYSTEM STRUCTURE FOR SOFTWARE RELIABILITY IN THE ENROUTE AIR TRAFFIC CONTROL SYSTEM

### PRINCIPAL INVESTIGATOR

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Pittsburgh, Pennsylvania 15260

### AMOUNT

1980 - \$56,000  
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### TENURE OF CONTRACT

September 1980 - August 1981

### MONITOR

David F. Clapp, DTS-534  
U.S. Department of Transportation  
Transportation Systems Center  
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### ABSTRACT

The objective of this research project is to develop techniques and algorithms which can be applied to the Enroute Air Traffic Control (ATC) System to ensure continuity of its operation in the face of possible software faults. Using the Flight Data Message Processing (FDMP) subsystem of the ATC system as a test case, the project will

- 1) Develop techniques to ensure the integrity of the Flight Data Processing data base;
- 2) Develop techniques to confine, correct and bypass errors in the Flight Data Message Processing subprograms and subroutines;
- 3) Investigate the concept of atomic actions and their applicability to data base and process recovery, backup and restart; and
- 4) Develop techniques to ensure the consistency of interleaved execution of processes and transactions in the Flight Data Message Processing Subsystem.

## EVALUATION OF ACHIEVABLE INTERNAL COMBUSTION ENGINE ECONOMY AND EMISSIONS PERFORMANCE BY IMPROVED ENGINE CONTROL

### PRINCIPAL INVESTIGATOR

Enoch J. Durbin  
Department of Instrumentation and Control Lab  
Princeton University  
24 Aero. Lab—Forrestal Campus  
Princeton, New Jersey 08540

### AMOUNT

1977 - \$75,705  
(\$8,512 in university funds)  
1978 - \$89,000  
(\$3,500 in university funds)  
1979 - \$90,000  
(\$18,647 in university funds)

### TENURE OF CONTRACT

July 1977 - March 1981

### MONITOR

Herbert H. Gould, DTS-323  
U.S. Department of Transportation  
Transportation Systems Center  
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Cambridge, MA 02142  
(617) 424-2294

### ABSTRACT

One of the current trends for the improvement of fuel economy of spark ignition engines for a given set of emission standards includes the optimization of engine control parameters such as air-fuel ratio, spark advance and exhaust gas recirculation at a number of relevant engine speed-torque points in the steady state. The role of the dynamic scatter of air-fuel ratio and spark timing on engine performance, however, has not been established. The purpose of this research is to: (1) establish by experiment the variability of the above engine parameters, (2) identify by experiment the im-

provements in fuel economy that can be obtained by improving dynamic control, and (3) define engine control elements that are technically feasible and that would yield improved fuel economy within the constraints of manufacturability, drivability, and compatibility with the presently projected engine control and emission control systems.

The results of such identification should be to indicate achievable fuel economy performance at a given level of engine emissions and thereby aid in the development of governmental standards for performance.

### STATUS

This research is in the third phase of a three year contract. During the first year, the contractor instrumented a vehicle for the measure of air flow, fuel flow, spark timing, manifold pressure, crank angle, and flame front arrival times. During the second phase, the contractor measured the transient behavior of air and fuel flow, manifold pressure, fuel consumption, and emissions in order to design a control scheme for tighter control. The current work consists of implementing and evaluating the control scheme.

### APPLICATIONS

The auto industry has become sensitized to the importance of dynamic control in engine parameters. The issue of achieving substantially improved economy and emissions performance from inservice internal combustion engines is paramount. It is expected that after the third year's work is completed, sufficient data will be obtained to determine whether tighter dynamic control of the listed engine parameters can be of benefit in terms of fuel economy, emissions, and drivability.

The results of this research are of use to the Federal Government (Department of Transportation, Department of Energy, Environmental Protection Agency), and are being monitored by the automotive industry. Specific companies who have been in communication with the researcher include Ford Motor Co., Eaton Corp., Toyota, and Volkswagen.

## ALTERNATIVE POLICIES FOR IMPLEMENTING TRANSIT CORRIDOR LAND-USE MANAGEMENT AND DEVELOPMENT

### PRINCIPAL INVESTIGATOR

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Princeton University  
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Princeton, New Jersey 08540

### AMOUNT

1978 - \$25,956  
(\$4,484 in university funds)

### TENURE OF CONTRACT

October 1977 - October 1979

### MONITOR

Richard Cohen, UPP-31  
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### ABSTRACT

Transit lines have not always contributed significant, positive changes to urban development. In addition, patronage derived from suburban regions on transit systems is often low, primarily because the transit serves low density areas. This research examines policies and institutional mechanisms for integrating urban corridor land-use planning and development into transit systems planning. Specifically, the research investigates economic and institutional forces that could be brought to bear in a coordinated land-development transit program for transit stations in an urban corridor.

### STATUS

The research on this project has been completed and the final report is being prepared.

### SUMMARY

The research involved case studies on joint development in several areas, and resulted in four main chapters in the final report. Chapter one a) discusses and presents recommendations concerning federal involvement in joint development policy, b) traces the history of joint development regulation, and c) presents recommendations for future policy development. Chapter two discusses the Baltimore case study in which Baltimore's governmental structure was examined to determine government or policy instruments needed to implement joint development around transit stations. Chapter three examines a number of joint development sites in the Northeastern United States, including Philadelphia, Newark, N.J., and Greenwich and Stamford, Connecticut, discusses both public and private projects impleted at these sites and includes construction and land acquisition costs for joint development projects. Also included are recommendations of priorities for development projects which have been the most successful. Chapter four presents a method for evaluating the impact of corridor-wide residential policies on transit ridership and demonstrates the effect of providing various levels of residential density in transit corridors.

### APPLICATIONS

This research will assist communities in estimating costs for development and will provide guidelines for executing joint development projects. Preliminary findings are being used by the State of New Jersey. A station policy paper was prepared with guidelines for local communities to run their own railroad stations. The findings encourage more joint development of stations, thus requiring less subsidization.

This research is being closely coordinated with the New Jersey DOT, the Union County (N.J.) Transportation Coordinating Committee, the Borough of Rutherford (N.J.), PATCO, and the municipal governments of Dover and Manasquan in New Jersey.

## DEVELOPING A COORDINATED TRANSPORTATION PLANNING PROCESS FOR COASTAL ZONE MANAGEMENT

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1978 - \$53,984  
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### TENURE OF CONTRACT

July 1978 - January 1980

### MONITOR

Norman Cooper, P 23  
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(202) 426-4380

### ABSTRACT

This research seeks to develop a model for a coordinated multi-modal transportation planning process in the context of coastal zone management. This process addresses planning requirements for transportation demands as they interact with competing environmental and energy demands. Therefore, the planning process studied include not only the transportation planning process but the environmental and energy planning processes as well, and the way in which all three processes combine to facilitate or hinder transportation planning in New Jersey's coastal zone. The project utilizes network analysis to study the actual interorganizational communications patterns between participants in each of these planning processes. These actual patterns of communication are then compared with legally mandated ones. The results of this comparison

enable the development of a unified structure for planning transportation in the state coastal zones.

### STATUS

All of the required review commentary and permitting procedures at both state and federal levels has been identified and described. A survey was undertaken of planners at all levels of government who are involved in transportation planning as well as related areas such as environment, energy, and land use. The analysis of the survey data concentrated on three factors: (a) patterns of interagency interactions; (b) the quality of those interactions; and (c) the attitude and opinion differences between professionals in various agencies. Using this base, the general hypothesis that attitude and opinion differences are associated with interactional frictions (i.e. competing transportation, environmental and energy demands), which disrupt the smooth functioning of the entire system, was tested.

### APPLICATIONS

The major product of this study is a set of recommendations for state and federal agencies, detailing how to structure a transportation planning process for state coastal zones. Proposals are offered to reduce the differences in opinions and attitudes held by professionals in various transportation and other planning agencies. The results assist government agencies in streamlining the Environmental Impact Statement and the A-95 review procedures.

The New Jersey Department of Environmental Protection as well as the New Jersey Department of Transportation have followed the Project's progress, as this is the first study of its kind on how the planning process actually does work. New Jersey Department of Higher Education has provided additional funding.

## LONGITUDINAL CONTROL TO IMPROVE PERFORMANCE RELIABILITY AND SAFETY IN AUTOMATED VEHICLE SYSTEMS

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1978 - \$55,421  
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### TENURE OF CONTRACT

September 1978 - August 1980

### MONITOR

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### ABSTRACT

This research project addresses the problem of designing longitudinal control systems for advanced automated guideway transit (AGT) and automated highway system vehicles (AHS). The primary objective of the research is to develop control system designs which when compared with existing designs will result in improved vehicle performance, reliability, and safety. Initially, the research concentrated on development of vehicle, propulsion, and braking system models in which significant nonlinearities are included. These models are nondimensionalized in order for the results to be as general as possible. Using these models, the automatic control systems are designed using a novel approach based upon the model-reference concept. The effects of spacing policy and system nonlinearities on vehicular dynamic response are evaluated. Longitudinal control for a mix of vehicles, particularly large

trucks, is examined in the automated highway portion of this study. The project concludes with an evaluation of the practicability of vehicle inspection systems to assure safe, reliable operation.

### STATUS

The AGT portion of the study (small vehicles propelled with D.C. rotary motors) has been completed. The primary conclusions to date are as follows: (1) the model reference control concept provides a simple yet very efficient approach to regulating vehicular longitudinal dynamics; (2) various spacing policies are easily implemented; (3) spacing policy is paramount in determining string behavior; and (4) jerk and acceleration limiting can be accommodated inside the model generator making this structure easily instrumentable.

The development and evaluation of controllers based upon the model-reference control concept is nearing completion. Other areas of the research underway are (1) Examining the effects of spacing policy on systems operations and vehicular dynamic response and (2) developing control systems and evaluating the response of large vehicles involved in automated freight movement on automated highways.

Finally, a nonlinear computer simulation model to evaluate braking system failure was developed, based on models previously developed by the Highway Safety Research Institute and the Applied Physics Laboratory for NHTSA. Simulations will be used to evaluate tests which would detect braking system failures.

### APPLICATIONS

Several large cities are scheduled to install automated downtown people mover systems. The automatic control of vehicle spacing (longitudinal control) to achieve maximum capacity and safety is a key technical issue. This research will contribute toward the solution of longitudinal control of automated vehicles and will be of use to UMTA planners and local transit authorities and their engineering support contractors.

## LATERAL STABILITY AND DYNAMIC RESPONSE OF RAM AIR CUSHION VEHICLES

### PRINCIPAL INVESTIGATOR

H.C. Curtiss, Jr.  
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Engineering Quadrangle  
Princeton University  
Princeton, New Jersey 08540

### AMOUNT

1979 - \$73,500  
(\$8,801 in university funds)  
1981 - \$79,689  
(\$9,162 in university funds)

### TENURE OF CONTRACT

June 1979 - September 1981

### MONITOR

Timothy M. Barrow, DTS-222  
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Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2758

### ABSTRACT

The objective of the research is to expand the understanding of the air suspension characteristics of tracked ram air cushion vehicles (TRACV) with emphasis on lateral/-directional behavior and vehicle response to guideway irregularities. The knowledge gained from this research is essential to evaluate the

viability of this high speed ground transportation concept. The analytical component of the study develops methods to predict aerodynamic forces and moments due to roll, yaw, and sideslip displacements for the purpose of determining the stability derivatives. Unsteady force due to irregularity of the guideway surfaces will be predicted. The experimental work involves the determination of static lateral/directional characteristics in a wind tunnel and the determination of the vehicle response to guideway nonuniformities using the Princeton Dynamic Model Track. Both of the experimental facilities have been used successfully in previous TRACV studies at Princeton. The theoretical and experimental results will be applied to the evaluation of vehicle stability and ride quality over typical guideway surfaces.

### STATUS

Unsteady theory for response of a vehicle to short wavelength guideway disturbances has been completed. The wind tunnel model for correlation of lateral/directional theory is also complete. The theory for lateral/directional aerodynamics is about 90% complete. Work is continuing on the model and guideway for unsteady experiments. The wind tunnel experiments and moving model experiments should be completed during July, 1980.

### APPLICATION

This research is directed towards developing experimentally verified prediction methods for the aerodynamics, dynamics and ride quality of Tracked Ram Air Cusion Vehicles, such that vehicle system trade-off studies for this advanced concept can be conducted on a sound basis.

## IMPROVEMENT IN RAIL VEHICLE DYNAMIC PERFORMANCE THROUGH CONTROL OF LINEAR MOTOR LATERAL AND NORMAL FORCES

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1979 - \$82,500  
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1981 - \$82,000  
(\$26,024 in university funds)

### TENURE OF CONTRACT

September 1979 - August 1981

### MONITOR

Matt Guarino, RRD-21  
Federal Railroad Administration  
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### ABSTRACT

The objective of this research program is the exploration of the use of linear motors to improve the dynamic performance of railroad vehicles. Improved vehicle stability, ride quality, traction capability, curving performance, track loading, and derailment safety may result from use of controllable lateral and normal forces, magnetic forces present in the motor, in

addition to those used for propulsion. Use of linear induction and synchronous motors in various configurations is being evaluated in locomotive and powered passenger rail vehicle applications. Experiments on the Princeton Dynamic Model Track will verify linearized analyses of the motor forces used in the system evaluation. Critical interactions between motor, vehicle and rails are being studied experimentally for a selected configuration to demonstrate the potential for improved vehicle performance.

### STATUS

The design and fabrication of a linear induction motor (LIM) has been completed. A package of computer programs needed to evaluate vehicle dynamic performance has been assembled. These programs are used to study the effect of increased LIM attraction force on vehicle stability. The evaluation of rail vehicle performance improvements (showing dramatic improvement in critical speed and response of least damped modes) has also been done. Finally, mathematical models for linear motor magnetic forces during truck motion have been formulated. Future work will concentrate on the testing of the LIM experimental models and development of LIM control systems.

### APPLICATIONS

The results of this research should provide the basis for future development of high speed conventional rail technology. Communication has been made with several potential users, including U.S. DOT, researchers at Massachusetts Institute of Technology, and four industries: MITRE Corp., General Electric, Urban Transportation Development Corporation (Canada), and Japanese National Railways.

## HIGHWAY CONDITIONS AND HIGHWAY ACCIDENTS: A MULTIVARIATE DESIGN MODEL

### PRINCIPAL INVESTIGATOR

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Mayaguez, Puerto Rico 00708

### AMOUNT

1980 - \$206,197  
(\$14,583 in university funds)

### TENURE OF CONTRACT

June 1980 - August 1982

### MONITOR

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### ABSTRACT

Many studies have attempted to relate certain roadway characteristics with traffic accidents. Usually only a few characteristics are considered. In recent years, State accident data systems have been computerized, and powerful new multivariate statistical methods have been developed. The objective of this research is to develop and validate a comprehensive model relating traffic accidents to highway, vehicle, and driver characteristics. The research will determine the usefulness of these new multivariate statistical methods for analysis of the highway accident problem.

## NON-DESTRUCTIVE DETERMINATION OF RESIDUAL SERVICE LIFE OF BRIDGE STRUCTURES

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1979 - \$72,806

### TENURE OF CONTRACT

June 1979 - June 1980

### MONITOR

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Transportation Systems Center  
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### ABSTRACT

The objective of this research is to devise a procedure to ascertain the residual service life of existing bridge structures. The research outlines an analytical approach which can be used to detect signs of distress or failure in a bridge structural system. With these analytical tools, new and existing structures can be examined periodically as a routine procedure. Then by studying the history of the dynamic response of the bridge, evidence of distress can be diagnosed, and failing components

can be located. Decisions can then be made regarding the future use of or a repair program for the structure.

### STATUS

Modifications of the dynamic analyzer, TDAB (Transient Dynamic Analysis of Bridges), for plane truss bridges and curved bridges have progressed according to schedule. The dynamic analyzers' capabilities was then extended by developing a computer code for curved bridges and a broader spectrum of traffic flow conditions. Verifications of the computer code have also been completed. The computer predictions for curved bridges show a close agreement with the experiment results reported previously by Professor Wilson of Duke University. The results for plane truss bridges compare favorably with the data for a railroad bridge reported in a study by the Association of American Railroads. Parametric studies for the dynamic responses to identify the Bridge Service Life Index are in progress.

### APPLICATIONS

Significant questions pertaining to bridge service life include how to ascertain the level of damage a structure has sustained over a period of time or due to a particular event, and what is the structure's residual service life even after an uneventful passage of time.

With an analytically-based diagnostic approach, such as the one developed in this project, component failures can be detected in sufficient time before structural damage becomes widespread. The result is the ability to save or even prolong a bridge structures' service life through strengthening or repairs.

## DEVELOPMENT OF A NORMATIVE METHOD TO PLAN URBAN STRUCTURE CONSIDERING SPATIAL AND TEMPORAL INTERACTIONS AMONG TRANSPORTATION, POPULATION, EMPLOYMENT AND PUBLIC FACILITIES

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1978 - \$59,900  
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### TENURE OF CONTRACT

June 1978 - May 1980

### MONITOR

Robert Crosby, DPB-25  
Research and Special Programs Administration  
U.S. Department of Transportation  
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### ABSTRACT

Traditionally, urban structure has been studied either at a subsystem level where components of the system are analyzed and isolated from the rest of the system, or at the total system level using simulations. In the first approach interactions between the components are neglected and in the later approach the decisions and the dynamics in the system are obscured by the simulation.

A normative methodology is proposed which attempts to synergistically combine micro- and macro-level models which (a) explicitly consider the dynamic nature of urban structure processes, (b) assume decision-makers in the system behave rationally, and (c) include interactions among the major components: population, transport system and employment/public

facility/residential locations.

The urban structure control problem can be decomposed into a master problem and several subproblems. The subproblems are formulated as decision-optimizing models among the components. The master problem is formulated as an aggregate dynamic model that accounts for the interactions, and their time constants, between the components. The exogenous inputs to the system include policies related to transportation, land-use, and energy, that affect urban structure. The proposed model will be useful for evaluating various policy alternatives to produce the desired urban spatial form.

### STATUS

The preliminary version of the dynamic model of the urban structure has been completed. More recently, effort has been focused on (a) refining the mathematical representations where necessary and (b) programming the mathematical equations and expressions of the model for simulating the urban structure process on an interactive graphics computer system. Once the model has been implemented on the computer, the accuracy and the utility of the model will be evaluated. If the model appears to be reasonable and plausible, it will be used to explore some policy questions related to energy and environmental impacts of decisions on transportation and other large facilities.

### APPLICATIONS

The results of this research will be useful in examining the dynamics of the interactions between transportation systems, employment, land-use patterns and public facilities and in analyzing transportation related policies. Specifically, the results will be valuable to transportation planners at all levels, to urban planners interested in community development and urban growth, and to policy analysts dealing with transportation energy. The interest will be evaluation of policies in the perspective of energy considerations.

**THE DEVELOPMENT OF UTCS/NETSIM/ICG: AN INTEGRATED URBAN TRAFFIC CONTROL SYSTEM—NETWORK SIMULATION—INTERACTIVE COMPUTER GRAPHICS PROGRAM**

**PRINCIPAL INVESTIGATOR**

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**AMOUNT**

1980 - \$80,000  
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**TENURE OF CONTRACT**

June 1980 - June 1981

**MONITOR**

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**ABSTRACT**

The evaluation of the potential effectiveness of user intervention in an Urban Traffic Control System requires research tools which are not currently available. This research concerns the development of an Integrated UTCS/NETSIM/ICG (Urban Traffic Control System—Network Simulation—Interactive Computer Graphics) computer program which would 1) provide pseudo real-time graphic displays of signal settings, surveillance data and system performance measures, and 2) simulate user intervention by providing for interactive capabilities.

The development of UTCS/NETSIM/ICG will support research in a) the ongoing development and evaluation of existing and new traffic control systems, b) network incidence detection, and c) emergency vehicle routing through networks.

## A STUDY OF PARTICULATE FORMATION AND RADIANT HEAT LOSS IN DIRECT INJECTION - TYPE DIESEL ENGINES

### PRINCIPAL INVESTIGATOR

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### AMOUNT

1980 - \$61,249  
(\$9,873 in university funds)

### TENURE OF CONTRACT

June 1980 - May 1981

### MONITOR

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Transportation Systems Center  
Kendall Square  
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(617) 494-2452

### ABSTRACT

The objective of this project is to obtain information needed for the design of a high-efficiency direct injection-type diesel engine with minimum smoke emission. This will be accomplished by changing engine design variables including combustion chamber, geometry, injection parameters, etc. The project will 1) investigate the formation of diesel particulate in the cylinder during the combustion period by obtaining continuous, flow-type particulate data at different engine crank angles and at different locations of the combustion chamber; 2) study the radiant heat loss in diesel combustion by taking radiant heat transfer data from the combustion chamber; and 3) compare and analyze these data a) to provide information needed to minimize diesel particulate emissions and b) to improve the energy efficiency of the direct injection-type diesel engine.

## **USING SCHOOL BUSES TO TRANSPORT ELDERLY AND HANDICAPPED NON-WHEELCHAIR USERS: A NATIONAL FEASIBILITY STUDY**

### **PRINCIPAL INVESTIGATOR**

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Liberal Arts College  
Shaw University  
118 East South Avenue  
Raleigh, North Carolina 27600

### **AMOUNT**

1978 - \$57,000  
(\$3,731 in university funds)

### **TENURE OF CONTRACT**

June 1978 - April 1980

### **MONITOR**

Leslie Baldwin, P-23  
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### **ABSTRACT**

This research investigates the use of school buses for transporting elderly and non-student non-wheelchair handicapped persons during non-peak hours. An analysis is performed of the barriers (other than insurance issues) to such utilization including state laws which prohibit the use of school buses for purposes other than transporting students from home to school and back; State Utilities Commission and State Department of Motor Vehicles regulations which present problems in obtaining permission to use the school bus; jurisdictional disputes over school buses; the school buses physical suitability for use by elderly and non-wheelchair handicapped persons; and the operational impacts of safety requirements.

Case studies in three jurisdictions have been conducted. The study presents a synthesis of the findings of the investigation of these barriers. The study concludes with a written analysis of the feasibility of utilizing school buses and recommendations on how to overcome barriers to such utilization. A User's Manual for the use of local and state planners will be prepared.

## INVESTIGATION OF THE BASIC FORCES INVOLVED IN THE ADHESION OF ICE TO HIGHWAY SURFACES

### PRINCIPAL INVESTIGATOR

T. Ashworth  
Department of Physics  
South Dakota School of Mines and Technology  
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### AMOUNT

1977 - \$59,513  
(\$3,833 in university funds)  
1978 - \$60,000  
(\$4,139 in university funds)  
1979 - \$50,000  
(\$3,511 in university funds)

### TENURE OF CONTRACT

July 1977 - December 1980

### MONITOR

Brian H. Chollar, HRS-23  
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### ABSTRACT

The objective of this study is to investigate the basic nature of the adhesive forces between ice and highway paving materials. This study uses many physical techniques to investigate the relationship between the physical characteristics of paving materials and ice adhesion. The fraction of the total adhesive forces attributable to mechanical interlocking and

chemical interactions is being determined. Interfacial energy characteristics are being studied as they relate to the purity of water and temperature. Investigations of the relationship between the chemical parameters of coating or surface treatments and ice adhesion are being conducted. Characteristics of permanent surfaces are being investigated. The relative potential of preventing wetting to take place (hydrophobic treatment) versus the reduction of the ice to surface bond in a wetting situation (ice-phobia surfaces) is being investigated.

### STATUS

Most of the adhesional strength tests have been completed; some immersional heats of wetting and moisture absorption experiments are also complete. Results from the surface area, immersional wetting, and moisture experiments indicate a very complex interaction between the water molecules, hydration products, of the cement and the natural grains of the aggregates. The future work on this project will consist of the completion of the interfacial tests and moisture tests, and the preparation of the final report.

### APPLICATIONS

The ultimate objective of this project is highway icing mitigation, and, therefore, more effective ice control and removal. Based on the findings of this work, recommendations will be made as to how the surface of roadways ought to be treated and/or designed to prevent the adhesion of ice to road surfaces.

Potential users who are interested in this project include the Midwest Research Institute, BJORSTEN Laboratories, South Dakota Department of Highways, Texas Transportation Institute, and Southwest Research Institute.

## SUPERPLASTICIZED CONCRETE FOR REHABILITATION OF THE BRIDGE DECKS AND HIGHWAY PAVEMENTS

### PRINCIPAL INVESTIGATOR

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South Dakota School of Mines and Technology  
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Rapid City, South Dakota 57701

### AMOUNT

1979 - \$119,000  
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### TENURE OF CONTRACT

August 1979 - July 1981

### MONITOR

Thomas J. Pasko, Jr., HRS-22  
Federal Highway Administration  
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### ABSTRACT

One of the most critical problems facing the highway industry is the need to determine the most effective and the most economically advantageous means to rehabilitate distressed concrete bridge decks and pavements. There is also a need to determine the effect of continued traffic on an adjoining lane to the overlaid concrete and the effect on air-void systems, durability characteristics, and other properties of the hardened overlaid concrete.

The object of this research is to develop guidelines for assuring the trouble-free placement of tough, high-strength, high density, durable concrete for bridge deck construction through the use of superplasticizers and steel fibers. The study has two phases. The first investigates the basic properties of concretes made with superplasticizers through the use of experimental mixtures conforming to the requirements dictated by statistically valid factorial designs, so that analysis of variance can be used in the evaluation. The second phase extends the findings

into an evaluation of superplasticized concrete containing steel fibers. The data to be collected will be descriptive of the properties of the concrete ingredients, properties of the fresh concrete, placement characteristics and measurements of the hardened concrete such as durability, strengths, and elastic properties over time. Relationships among the parameters will be defined, as well as the sensitivities of the properties to changes in other variables.

### STATUS

An annotated bibliography consisting of about 500 references is complete. Tests are being performed on reinforced concrete. The statistical analysis of 41 exploratory mixes is complete; based on these results, two appropriate mixes have been selected for intensive study. One of the mixes with high workability will be suitable for structural concrete. The other mix with medium-good workability and high cement content will be suitable for bridge deck replacement. Numerous test area in progress to study the properties of the hardened concrete. In the future, the effects of retempering will be studied for both the selected mixes, and further tests on their properties will continue.

### APPLICATIONS

The final report at the end of the first phase includes positive recommendations about the suitability of superplasticized concretes for bridge deck overlays. Suitable mixes and procedures to be followed for trouble free placement are suggested.

By the end of the second phase, the improvements in the performance characteristics that could be achieved with the addition of steel fibers to the superplasticized concretes will be determined. The result will be positive recommendations and guidelines for assuring the trouble-free placement of durable concrete through the use of superplasticizers and steel fibers. Two other valuable results of this research will be a state-of-the-art report and an annotated bibliography on superplasticized concretes.

## STUDY OF THE CAPABILITY OF RISK ANALYSIS FOR THE SUPPORT OF THE FORMULATION OF REGULATIONS FOR THE TRANSPORTATION OF HAZARDOUS MATERIALS

### PRINCIPAL INVESTIGATOR

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Safety Department  
Institute of Safety and Systems Management  
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### AMOUNT

1979 - \$87,300  
(\$8,848 in university funds)

### TENURE OF CONTRACT

September 1979 - August 1980

### MONITOR

Joseph Nalevanko, DMT-401  
Research and Special Programs Administration  
U.S. Department of Transportation  
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(202) 472-2784

### ABSTRACT

A critical need is recognized to exist for effective risk analysis capabilities to support hazardous materials transportation regulatory decision-making. However, transportation risk analysis methodologies have so far proven to be even less convincing, and perhaps even more controversial, than those

that have been applied to fixed hazardous facilities, such as nuclear power plants. This multidisciplinary research program investigates indepth both analytically and experimentally all important aspects of the various techniques of risk estimation, risk mitigating measure, cost-benefits evaluation, and residual risk-acceptability evaluation, so as to establish a comprehensive understanding of their strengths, weaknesses, feasible data requirements, and conditions for applicability. Guidelines will thereby be devised and related documentation and presentations will be provided to aid the development and application in the future of the best possible techniques by all agencies concerned with the regulation of hazardous materials transport.

### STATUS

The research of this project is finished and the final report is in progress. The completed project consisted of the following tasks: a) development of an inventory of failure mode probability estimates applicable to the transportation of hazardous materials; b) development for generalized risk estimation model that can be applied to all shipment modes; and c) investigation of the feasibility of relating risk estimation methodologies to regulatory changes.

### APPLICATIONS

The study findings will allow construction managers and planners to develop an understanding of productivity in transportation construction based on an evaluation of construction costs.

**AIR—FUEL MIXTURE SENSING AND CONTROL IN AUTOMOTIVE ENGINES****PRINCIPAL INVESTIGATOR**

J. David Powell  
Department of Mechanical Engineering  
Stanford University  
Stanford, California 94305

**AMOUNT**

1980 - \$84,995

**TENURE OF CONTRACT**

June 1980 - May 1981

**MONITOR**

Thomas Trella, DTS-323  
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**ABSTRACT**

This research is an effort to provide a data base, define control strategies, and develop techniques for best utilization of microprocessors in the control of automotive engines. The object is to control air fuel mixtures in order to maximize the efficiency of spark-ignition engines constrained for emissions. Specifically, this research effort addresses two areas. The first investigates the use of cylinder pressure-time resolved data to define air/fuel ratio algorithms. Precise control of this variable in engines through a programmed mini-computer is sought. In the second effort, assessments will be conducted to quantify the fuel economy potential provided by valve profiling control (e.g., an additional air/fuel mixture control variable), and to define the tradeoff relative to fuel economy, performance, and emissions. Based on these assessments, valve profiling calibrations will be established and computer based actuators will be developed to provide control of this variable in real engines.

## DEVELOPMENT OF ULTRAHIGH CARBON (UHC) STEELS FOR AUTOMOTIVE APPLICATIONS

### PRINCIPAL INVESTIGATOR

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School of Engineering  
Stanford University  
Stanford, California 94305

### AMOUNT

1980 - \$108,000

### TENURE OF CONTRACT

July 1980 - July 1983

### MONITOR

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### ABSTRACT

Plain carbon steels containing 1 to 2% carbon are called ultrahigh carbon (UHC) steels. These steels are normally con-

sidered to be hard and brittle. Recent research at Stanford University on small UHC steel castings has shown that these steels can be made strong and tough by unique thermal-mechanical processing treatments. Such strong and ductile UHC steels appear promising for many automotive components. These steels are inexpensive and they do not rely on alloying additions that are scarce in our country. The UHC steels are also superformable which means that they can be fabricated into intricate shapes avoiding energy consuming machining operations.

The objective of this project is to determine the feasibility of preparing thick UHC steel plates from medium size castings. These plates will be fully characterized for their microstructure and their room temperature mechanical properties including impact, fatigue and fracture resistance. Once the plates are made and characterized, two automotive parts will be fabricated by the Chassis Engineering Group of the Ford Motor Company. One part will be superplastically formed (a side gear to a transmission) and the other part fabricated at room temperature (an engine bracket mount). Successful application of UHC steels to automotive parts will save energy during fabrication, reduce the use of scarce materials such as nickel, tungsten and chromium, and save weight from the increased strength of UHC steels over conventional steels.

## IMPROVING FLOW MANAGEMENT AND CONTROL VIA SHORTEST PATH ANALYSIS

### PRINCIPAL INVESTIGATOR

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Graduate School of Business Administration  
University of Texas, Austin  
Austin, Texas 78712

### AMOUNT

1977 - \$67,524  
(\$3,705 in university funds)  
1978 - \$60,000  
(\$3,342 in university funds)  
1980 - \$98,046  
(\$5,632 in university funds)

### TENURE OF CONTRACT

September 1977 - September 1981

### MONITOR

Robert Dial, UTP-10  
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### ABSTRACT

Shortest path and maximum flow analysis are major analytical components of quantitative models for improving flow management and control. Many of the significant real world applications using such analysis, however, involve problems that are far larger than the current software can handle on existing computers. The purpose of this project is to conduct research on effective mathematical methods and computer implementations for solving large-scale shortest path and maximum flows problems. Specifically, this research project is to improve computer tools for flow management and control by a) conducting a full-scale interdisciplinary investigation of in-core and out-of-core shortest path algorithms and b) developing new maximum flow algorithms. The research investigation is both theoretical and empirical and involves an in-

tensive application of the combined skills of operations researchers, mathematical programmers, and computer systems analysts in the network area.

### STATUS

Among the significant results of this project is the development of important new computer tools, including an in-core, out-of-core shortest path code which is as fast as the best in-core code while allowing much larger problems to be solved. Furthermore, a maximum flow code has been developed which is at least an order of magnitude faster than the fastest previous maximum flow algorithm. The maximum flow algorithm devised and implemented by the research team requires only one-third of the computer memory required by previous codes and runs at least ten times faster than the fastest previous maximum flow code. The efficiency of these procedures is based on new specialized algorithms, labeling techniques, lists processes, and software interfaces to exploit large-scale graph structures. The current research is completed and the contract has been renewed, with plans to develop more advanced algorithms based on results achieved so far.

### APPLICATIONS

The solution algorithms resulting from this effort substantially increased the solution capabilities of current DOT systems. These tools have already been incorporated into the UMTA software library for distribution to transportation planners. Thus, these results will have an immense impact since there are approximately 300 different groups using these UMTA software systems. Additionally, reducing memory requirements will allow these important planning and evaluation tools to be run with smaller computer configurations, thereby producing cost savings as well as making these tools available to new groups of users who do not have large-scale facilities.

The benefits of the new knowledge derived from this project reaches far beyond transportation planning. For instance, the U.S. Department of Treasury used the in-core our-of-core shortest path codes as the primary benchmark in a \$10 million computer acquisition decision.

## IMPROVEMENT OF LARGE SCALE NETWORK SOLUTION PROCEDURES

### PRINCIPAL INVESTIGATORS

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University of Texas at Austin  
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### AMOUNT

1979 - \$49,745  
(\$2,738 in university funds)

### TENURE OF CONTRACT

September 1979 - August 1980

### MONITOR

Robert B. Dial, UPM-20  
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### ABSTRACT

One of the most widely used classes of mathematical optimization techniques by transportation planners and traffic engineers are network models and algorithms. In particular, the trans-shipment network problem appears as a major subproblem within model formulations for such problems as postal and bus route scheduling, dial-a-ride services, truck dispatching, evaluation of regulatory and legislative actions upon goods movement, design of urban and suburban road networks, aircraft scheduling and route selection, aircraft re-

fueling, budget allocation, facilities location, line scheduling, and bus driver assignment. For these reasons, many leading transportation experts have stated that one of the pressing needs of the transportation community is for an in-depth original research study to develop efficient and effective mathematical methods and computer implementation techniques for solving trans-shipment problems. The goal of this research is to produce procedures capable of solving trans-shipment problems at least 200 times faster than current state-of-the-art commercial linear programming systems. Further, these procedures can be anticipated to greatly increase the solution capabilities of medium size computer systems which have a small amount of central computer memory.

### STATUS

New algorithms for solving capacitated trans-shipment problems have been developed and implemented on the computer. Plans are to complete the testing and document the results of this project by September 1980. The results of the testing indicate that this research has substantially improved the solution capabilities for capacitated trans-shipment problems.

### APPLICATIONS

The results of this research are expected to be used in traffic equilibrium models at MIT and University of Maryland. UMTA expects to make extensive use of these computer systems. The Federal Railroad Administration is another potential user.

## THE IMPACT OF THE INTERSTATE HIGHWAY SYSTEM ON NON-METROPOLITAN GROWTH

### PRINCIPAL INVESTIGATOR

Ronald Briggs  
Program in Political Economy  
University of Texas at Dallas  
2601 Floyd Road (P.O. Box 688)  
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### AMOUNT

1979 - \$46,102  
(\$12,783 in university funds)  
1980 - \$702

### TENURE OF CONTRACT

June 1979 - October 1980

### MONITOR

Joseph H. Meck, DPA-32  
Research and Special Programs Administration  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4228

### ABSTRACT

In the 1970's nonmetropolitan areas experienced a resurgence of demographic and economic development. Many writers suggest that transportation has played a key role in this re-emergence. Since the Interstate Highway System is the single most significant recent change in nonmetropolitan transportation, the objective of the research is to establish its role in stimulating the recent nonmetropolitan development. Contrary to common conceptions, the research is expected to show that the effect of the interstate system was largely permissive. Rather than providing a direct stimulus to development, its effect has only been felt through interaction with fac-

tors producing change, such as lower labor costs for manufacturing and increased leisure time. Consequently, the presence of an interstate highway is no guarantee of a community's development. The goal of the research is to identify the factors which have interacted with transportation to produce development.

### STATUS

The final report is in preparation.

### SUMMARY

Three analytic techniques were utilized: a) a simple linear and additive model, b) a recursive model, and c) an analysis of variance model, which were used to examine the effect of the interstate highway system on population growth and employment change in the 1970's. An examination of the interaction between the interstate highway system, population growth, employment growth, metropolitan overspill and recreation development was also undertaken.

The results of the research show strong evidence for a causal impact of interstates on migration, since the opening of interstate highways during one decade is followed by above average rates of migration during the succeeding decade. Thus, the results suggest a more important role for the interstate system in stimulating both population growth and industrial development. The results also identify the types of industries benefitting most from interstate development.

### APPLICATIONS

The results of the research are of value to persons concerned with stimulating economic development in rural and non-metropolitan areas, as well as to persons attempting to assess the likely future impacts of highway projects on particular communities.

## A NONLINEAR ANALYSIS OF LIQUID SLOSHING IN RIGID CONTAINERS

### PRINCIPAL INVESTIGATOR

Jack Y. K. Lou  
Department of Civil Engineering  
Texas A&M University  
College Station, Texas 77843

### AMOUNT

1979 - \$75,500  
(\$4,219 in university funds)  
1981 - \$80,000  
(\$4,378 in university funds)

### MONITOR

Rudolph R. Hegmon, HRS-12  
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U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
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### ABSTRACT

Liquid sloshing in a moving container constitutes a broad class of problems of great practical importance with regard to the safety of transportation systems. It is speculated that the reason liquid carrying vehicles have higher accident rates is partially attributable to the large movement of the contained liquid cargo.

Previous studies on this problem are only valid for small tank motions and thus have limited applications. The objective of this research is to properly account for the effects of large tank motions on liquid sloshing.

### STATUS

The work to be performed under this contract can be divided into four categories: Analytical Solutions, Numerical Techniques, Experimental Investigations, and Reports and Documentations. Mathematical analysis and some numerical computations have been completed. A series of physical experiments has also been performed.

The second phase of the project, which emphasizes a numerical simulation, will begin immediately following the completion of phase I work.

### APPLICATIONS

The study is directly applicable to problems of tank car derailments, tank truck accidents, and LNG ship tank damages. The results of the study will provide a better understanding of the fluid dynamics of a liquid inside a tank, e.g. dynamic impact loads and overturning moments due to sloshing, and will thus lead to improved designs and safety of liquid cargo transport systems. Professionals in the following organizations have been informed of results as the project progressed: Southwest Research Institute, Union Tank Car Company, University of Michigan's Highway Safety Research Institute, and El Paso LNG Company.

## THE IMPACT OF TECHNOLOGICAL CHANGES IN TRANSPORTATION NETWORKS ON REGIONAL PRODUCTIVITY AND DEVELOPMENT

### PRINCIPAL INVESTIGATOR

W. R. Roeseler  
Department of Urban Regional Planning  
Texas A&M University  
College Station, Texas 77843

### AMOUNT

1979 - \$80,600  
(\$4,901 in university funds)

### TENURE OF CONTRACT

June 1979 - August 1980

### MONITOR

Joseph H. Meck, DPA-32  
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U.S. Department of Transportation  
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Washington, D.C. 20590  
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### ABSTRACT

The objective of this research is to examine empirically the effects of technological changes in two major transportation networks, interstate highways and railways, on the economic development of the region in which they operate. The primary

test region is the southeastern section of Texas, although pertinent experience of other regions is cited in support of the research findings. First, a time-series analysis is performed to relate changes in the networks to changes in the regional economy and to specific selected industries within the region. Second, a simultaneous model is developed and estimated in order to account for the interactions and interrelationships between the two networks and for the two-way causality which exists between the regional economy and the throughput of its transportation networks. Third, the results of the estimations are employed to develop impact multipliers for the impact of technological changes.

### STATUS

Research is complete and the final report is in preparation.

### APPLICATIONS

The specific techniques developed in this project will be useful in connection with similar analyses of regional productivity in other locations and/or with other modes. The research can be used in cost effectiveness evaluation of technical changes as well as development of predictive models in transportation. Potential users include the Transportation Research Board, Midwest Research Institute, and several private companies.

## OPTIMIZATION STUDY FOR ULTRASONIC FLAW DETECTION IN RAILROAD RAIL

### PRINCIPAL INVESTIGATOR

Don E. Bray  
College of Engineering  
Texas A&M University  
College Station, Texas 77843

### AMOUNT

1980 - \$50,364  
(\$1,844 in university funds)

### TENURE OF CONTRACT

June 1980 - May 1981

### MONITOR

Harry L. Ceccon, DTS-733  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2677

### ABSTRACT

The problem of rail failures has received considerable attention in recent years. This project addresses the transverse defect and detail fractures which constitute the second largest cause of rail failures in the United States.

The specific problem to be studied is the ultrasonic beam refraction pattern in the lead of railroad rail. The objective of the research is to use the beam refraction data to establish the effectiveness of current ultrasonic rail flaw detection systems, and to propose test methods that might significantly improve that effectiveness.

### APPLICATIONS

The results obtained will be used for improving inspection equipment design and use. The development and application of better inspection techniques will improve the operating safety of U.S. railroads and should have a positive effect on reducing the train derailment rate.

## DEVELOPMENT OF PROTOCOL AND COMBUSTION/EXPOSURE CHAMBER FOR EVALUATING COMBUSTION PRODUCT TOXICITY AND SMOKE RESULTING FROM BURNING TRANSPORTATION VEHICLE INTERIOR MATERIALS

### PRINCIPAL INVESTIGATOR

William A. Galster  
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Flammability Research Center  
391 S. Chipeta Way, Suite E  
University of Utah  
Salt Lake City, Utah 84108

### AMOUNT

1976 - \$25,000  
(\$50,000 in university funds)  
1977 - \$35,000  
(\$451 in university funds)  
1979 - \$66,000  
(\$828 in university funds)  
1980 - \$6,595

### TENURE OF CONTRACT

June 1976 - March 1980

### MONITOR

Charles W. McGuire, P-23  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4468

### ABSTRACT

The principal objective of this research is to design and test a simplified and meaningful protocol, using an appropriate combustion and exposure chamber utilizing only those parameters and physiological/behavior effects found to be most relevant in assessing the relative hazards of burning materials.

The project a) evaluates materials based upon the amounts of carbon monoxide, hydrogen cyanide, and other noxious gas generation and b) observes dose related effects upon neuro-

muscular performance, arterial blood gas status, and lethal involvement.

### STATUS

Evaluations of 30 materials including foams, resins, thermal plastics and natural polymers have been completed with support from industry, National Bureau of Standards, Federal Aviation Administration (FAA) and others in the Department of Transportation. Experience with a fire-retarded nylon upholstery fabric led the researchers to pose several questions concerning their passively ventilated combustion device and to seek an adequate means of comparing results from materials that generate incapacitating amounts of hydrogen cyanide. Experiments are being conducted examining the effects of changes in the combustion mixture caused by supplementing the passive air flow to the combustion zone of the furnace. Hydrogen cyanide exposures of rats performing the leg flexion avoidance paradigm and walking in an exercise wheel have been made to compare the sensitivity of two endpoints of incapacitation used to assess combustion toxicity. Correlations and possible explanations for any observed differences in results from four representative upholstery fabrics are being made comparing data from this project with that reported by FAA (CAMI). Any improvements suggested by these results will be incorporated in to the methods of this project.

### APPLICATIONS

A basic test protocol for evaluation of the relative toxicity of materials under smoldering and flaming conditions will be implemented to improve selection of safe materials for the interior of transportation vehicles. (The importance of this research to the transportation industry was highlighted by the BART fire.) The National Bureau of Standards has expressed interest in using this approach to a test protocol as a national standard.

## A NEW CONTINUUM MODEL FOR TRAFFIC FLOW

### PRINCIPAL INVESTIGATOR

Warren F. Phillips  
College of Engineering  
Utah State University  
UMC-41  
Logan, Utah 84332

### AMOUNT

1978 - \$52,732  
(\$1,500 in university funds)  
1979 - \$57,491  
(\$1,665 in university funds)

### TENURE OF CONTRACT

May 1978 - August 1980

### MONITOR

Diarmuid O'Mathuna, DTS-523  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2054

### ABSTRACT

The project has developed a kinetic microscopic model of traffic flow which gives results consistent with data over the entire range of traffic density. From the moments of the governing Boltzmann-type equation, there results continuum-type theories of successive levels of refinement for describing the dynamics of traffic flow.

The system of equations arising from the first four moments (zero through third) provides a basis for assessing all previously derived systems and appears adequate as a continuum model for traffic dynamics in all conceivable practical applications. The research seeks to perfect and validate this model.

### STATUS

Although, in a completely general formulation, the traffic flow is affected by all moments of the speed distribution, the

present study has shown that higher order moments have progressively small effects. It appears that the effect of variance is less than the effect of mean speed; the effect of skewness is less than the effect of variance, and so on.

A theoretical analysis was carried out using the general kinetic traffic flow model from which the new continuum formulation was derived. An experimental investigation was based on a large volume of data which has been collected by a research team at the Stanford Research Institute. The results achieved to date show that the effects of skewness can be neglected.

The present phase examined the effects of variance in traffic speed distribution through three continuum formulations. These three models were evaluated by comparing solutions which were obtained from these models to solutions which were obtained from the full kinetic model, in predicting dynamic traffic flow. In every case all of the traffic flow models were found to give the same result to within one percent over the entire range of position, flow rate, and speed.

From the results of this investigation, it appears that the "first order constant pressure model" is an adequate representation of traffic flow. This model seems to predict the same results as the more complicated higher order models for a wide range of traffic flow conditions.

### APPLICATIONS

Traffic flow models are critical elements of computer-based traffic simulators by engineers and planners to analyze flow control schemes such as ramp metering or lane diversion. This study's validated model will provide the framework for the control and optimization of service in large transportation networks, whether the objective is to maximize the throughput of vehicles, people or goods, or to achieve the greatest economy in fuel consumption or environmental pollution. The validated model will be useful both as a tool for upgrading the level of service in existing networks and as a design tool in the development of new systems.

The theories of traffic dynamics developed in this study are now being used by researchers at M.I.T.'s Electronic Systems Laboratory as a basis for traffic control schemes, which optimize traffic flow in terms of travel time, fuel economy, and other such measures of level of service.

## METHODOLOGY FOR THE DESIGN OF URBAN TRANSPORTATION INTERFACE FACILITIES

### PRINCIPAL INVESTIGATOR

Lester A. Hoel  
 Michael Demetsky  
 Department of Civil Engineering  
 University of Virginia  
 Charlottesville, Virginia 22901

### AMOUNT

1976 - \$64,575
(\$1,655 in university funds)
1977 - \$60,000
(\$6,978 in university funds)
1978 - \$70,000
(\$1,957 in university funds)

### TENURE OF CONTRACT

August 1975 - December 1980

### MONITOR

Norman G. Paulhus, I-25  
 U.S. Department of Transportation  
 400 Seventh Street, S.W.  
 Washington, D.C. 25090  
 (202) 426-4208

### ABSTRACT

The purpose of this research is to develop, test, demonstrate and disseminate to the user community a standard methodology for the design of ground transportation interface facilities, which may be either among different transportation modes, i.e., downtown bus or rapid rail terminals, or with intercity rail facilities. The specific objectives of the project's work areas are as follows:

1. To develop a set of flexible criteria for the evaluation of alternative station designs, with emphasis on potential implementation constraints and operational efficiency.
2. To develop a standard methodology for the layout and design of ground transportation terminals.
3. To apply the methodology to design new stations and to renovate existing facilities.
4. To investigate station design elements that are critical but for which little is yet known.
5. To disseminate this methodology to the transit user community for application.

### STATUS

During the initial phase of the research, emphasis was first placed on developing a general station design evaluation framework. Functional components of stations, including pedestrian movement facilities, line haul access areas, and communications facilities were identified. A set of generalized

terminal evaluation criteria were adopted, and for each criterion, the viewpoint of the user, the special users, and the operator was examined. These criteria result from an analysis of the following station components and issues:

1. Passenger Processing Performance
2. Environmental Conditions
3. Fiscal Considerations.

The level of satisfaction of these criteria was evaluated through the use of an interest-impact matrix. Both a cost-benefit (dollar) and subjective index were used in the ranking of design alternatives.

Procedures and techniques were then identified to determine the measures of the performance of transit station designs. Categories of measure were defined according to the manner by which they are treated in the design process as a result of policy, or as measures of performance and economic efficiency. Policy items considered included concessions, advertising, personal care facilities, telephones, acoustics, construction materials, design flexibility, parking facilities, and provisions for the handicapped. Performance measures were associated with passenger processing, passenger orientation, the physical environment safety, and security. The policy and performance considerations along with cost factors were used to specify a systematic transit interchange facility design methodology that is recommended to practitioners.

The methodology has been applied to develop new station designs for different transportation objectives and to the station renovation problem. The results of this effort served to test, refine, and demonstrate the procedures.

In addition, the station design methodology has been applied in order to understand more fully certain critical aspects of the station design problem, which include establishing decision models for the transit station design process and developing detailed station security planner procedures. In order to meet the objectives on research dissemination and validation on the design methodology, a national conference on passenger terminals was planned and conducted during the contract period.

### APPLICATIONS

The design of transit interface facilities is a major element in the urban transportation planning and design process. The methodology developed in this research will eliminate much of the preliminary study required for developing transit interchange facilities and through the use of an interest-impact framework, insure that human design objectives are being met.

Other applications or users include the following:

1. The Environmental and Public Transportation Branch of FHWA has used the materials in developing workshops on facilities for high occupancy vehicles.
2. The American Association of State Highways and Transportation Officials (AASHTO) is using the results of

this work in preparing a transportation facility design manual.

3. The report from this project has been used by the Transportation Research Board (TRB) Committee on Interface Facilities.

4. This research has been used by JHK Associates as background material in preparation of a FHWA public

transportation course.

5. The reports have been disseminated with good response, as indicated by evaluation forms returned, to state and local users.

6. This project served as the basis for a DOT sponsored national conference held in September 1980.

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## LIMITING PERFORMANCE APPROACH TO SYSTEM DESIGN

### PRINCIPAL INVESTIGATOR

W.D. Pilkey  
School of Engineering and Applied Science  
University of Virginia  
Thornton Hall  
Charlottesville, Virginia 22901

### AMOUNT

1978 - \$61,000  
(\$6,505 in university funds)  
1980 - \$100,000  
(\$1,720 in university funds)

### TENURE OF CONTRACT

June 1978 - April 1981

### MONITOR

Timothy E. Aloney, NRD-12  
National Highway Traffic Safety Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4862

### ABSTRACT

This project sets forth a program for the development of the technology and corresponding computational capability for evaluating the optimum structural performance characteristics of automobiles in providing passenger protection under collision conditions. This technology will apply to large-scale, realistic nonlinear car models and can be coupled to modern DOT/NHTSA nonlinear computational structural analysis capabilities. The goal is to develop the capacity of evaluating the limiting passenger protection performance of proposed and existing automobile configurations. In addition, the

capability is intended for use in the structural design of an automobile that provides the best possible passenger protection. The proposed effort is not related to the usual optimization studies but rather entails the development of the technology for a nonlinear limiting performance capability. The difference is significant, because the limiting performance capability does not depend heavily on the structural complexity (degrees-of-freedom) of the problem. Several useful computer capabilities are being developed and applied to practical crash problems.

### STATUS

During the first year of this project, the contractor made the SSOM (Safety Systems Optimization Model) operative. Several problems with the SSOM were identified and corrected. Currently, the contractor is working to extend the capabilities of SSOM through generalization and verification of the program. The objective is to refine the SSOM to make it a more user-oriented system and further validate the system.

### APPLICATIONS

This project will lead to characteristics for the perfect safe automobile. These so-called limiting performance characteristics can be used by the automobile designer as a measure of the success of a proposed design. At the outset, the designer can determine whether his design specifications are even feasible. Also, he can ascertain how much improvement is possible for his design.

The completed SSOM is expected to be used by NHTSA for rulemaking, and by automobile manufacturers for the design and development of safe vehicle structures and restraint systems.

Interest in the SSOM has also been expressed by CALSPAN.

## APPLICATION OF IMAGE PROCESSING TO VEHICLE GUIDANCE AND SAFETY

### PRINCIPAL INVESTIGATOR

Rafael M. Inigo  
School of Engineering & Applied Science  
University of Virginia  
Thornton Hall  
Charlottesville, Virginia 22901

### AMOUNT

1980 - \$85,500

### TENURE OF CONTRACT

September 1980 - May 1981

### MONITOR

Brooks Bartholow, DPB-70  
Research and Special Programs Administration  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4433

### ABSTRACT

This research involves the application of computer vision to automotive transportation guidance and headway control. Automotive vehicle control problems involving guidance and safety, which might benefit from this new technology, will be defined. The objective is to design an automated control system. This multifunctional sensor system consist of a) a data-collecting element (such as a TV camera), b) an interface to convert signals to digital form, and c) a computer to perform pattern analysis and generate vehicle control signals.

The project shall identify several current problem areas, estimate potential performance improvement based on technological trends, and establish priority research requirements.

## INTERACTION AND LOAD TRANSFER THROUGH TRACK-GUIDEWAY SYSTEMS

### PRINCIPAL INVESTIGATOR

C.S. Desai  
School of Engineering  
Virginia Polytechnic Institute and State University  
Blacksburg, Virginia 24061

### AMOUNT

1978 - \$70,000  
(\$8,800 in university funds)  
1979 - \$65,655  
(\$6,149 in university funds)  
1980 - \$79,855  
(\$5,201 in university funds)

### TENURE OF CONTRACT

January 1978 - May 1980

### MONITOR

John Putukian, DTS-741  
Transportation Systems Center  
U.S. Department of Transportation  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2206

### ABSTRACT

The objectives of the research are a) to investigate the interaction behavior of various components of track support structures such as guideway (rail), tie, ballast and sub-base by examining the stress-deformation behavior at the interfaces and b) to develop a numerical method for analysis and design of load transfer that can incorporate nonlinear behavior and three-dimensional geometry. Laboratory direct shear equipment has been constructed to test interfaces in different materials such as sub-base, ties, and ballast; the equipment can allow various modes of load applications. A numerical finite element technique with a new interface element has been developed in order to compute load transfer in nonlinear and three-dimensional track systems. The results will aid in the development of improved procedures for new designs and for improvements in existing guideway-track systems.

### STATUS

A numerical procedure, called RR (Resistance-Response) technique, has been proposed. It integrates three-, two and one-dimensional finite element schemes, and is based on a rather new approach for incorporating complex three-dimensional geometry and loading encountered in track structures. Design and construction of the dynamic multi degree-of-freedom shear device with translational loading for interfaces is completed. Determination of laboratory behavior of components such as wood in ties, ballast and soil has been done; for instance, cubical samples of wood have been tested by using a truly triaxial device available in the laboratory.

During the second year, the RR technique was programmed and used to predict behavior of track structures; this included selected field sections. The newly developed shear advice was used to determine behavior of interfaces under repetitive loads.

During the third year, the computer code was finalized and various aspects such as three-dimensional interaction effects, nonlinear behavior of soil, ballast, tie and interfaces were implemented. The program was debugged and implemented for the application aspects.

### APPLICATIONS

The analytical and experimental results will have significant impact on the current design procedures for track structures. The numerical model developed can be used both for the design-analysis of new track structures, allowing analysis and evaluation of new tracks with modifications in track components, and for improvements of existing track support structures. These improvements can be obtained by studying the influence of repeated loadings on the behavior of ballast, and the influence of types of materials on the behavior of ties and ballast.

These investigations will enhance the state-of-the-art of computer prediction of stress-deformation behavior of track structures, and of the behavior of interfaces under repetitive loads in two ways: a) by development of a general and rational computer model for prediction of track behavior, and b) by development and use of a new dynamic shear device for behavior of interfaces between track components. These procedures will lead to both cost effectiveness and safety improvements in the design and maintenance of tracks.

**SOCIO-ECONOMIC IMPACT OF INTRASTATE MOTOR CARRIER REGULATIONS ON RURAL DEVELOPMENT IN SOUTH CENTRAL VIRGINIA****PRINCIPAL INVESTIGATOR**

Joseph C. Campbell  
Virginia State College  
Box 37  
Petersburg, Virginia 23803

**AMOUNT**

1978 - \$71,000  
(\$6,316 in university funds)  
1980 - \$59,377  
(\$5,625 in university funds)

**TENURE OF CONTRACT**

September 1978 - October 1980

**MONITOR**

Laurence T. Phillips, P-54  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C.  
(202) 426-4420

**ABSTRACT**

One of the primary issues in the debate on regulatory reform in the trucking industry is the impact of reform on rural communities. One step towards resolving the issue is to obtain information on the characteristics and behavior patterns of rural transportation entrepreneurs. Thus, the objectives of this contract are:

- (1) to develop and delineate the relevant economic/transportation characteristics of users of common as opposed to contract carriers;
- (2) to highlight and analyze data on users of contract and common carriers with the goal of determining the impact of

their geographic location on their perception of the rates they are charged and the services they receive; and

(3) to explore the linkage between the socio-economic characteristics of various motor freight users and their past experiences and attitudes regarding their probable reaction to an increase in rates.

**STATUS**

During the first year of this effort, the research team acquired a data set collected by the Virginia State University Bureau of Economic Research and Development (BERD). The data were collected in 16 counties and five cities in South Central Virginia, an area which is rural, economically homogenous, and heavily dependent on truck transportation. The data base contains detailed information on the transportation/economic characteristics of users of intrastate contract and common carriers. In addition, preliminary behavioral data have been collected as to the potential actions of users of truck service if existing rate levels and service patterns were altered.

The first year's work resulted in the analysis of these data in the aggregate, and the comparison of characteristics and experiences of common and contract carrier users.

**APPLICATIONS**

The results of the study, as it relates to the net impact of the regulations of the Common Motor Carrier on the rural sector provides guidance to the Interstate Commerce Commission in the matter of promoting rural economic development through an "efficient" motor carrier. It also provides guidance on the extent to which deregulation is a viable alternative to the existing state of affairs. This study assesses the benefits and deficiencies of present trucking regulations in providing rural transportation services. The results of this study have been utilized by DOT in preparation of testimony for Congressional hearings on trucking deregulation.

## DEVELOPMENT OF IMPROVED URBAN TRAVEL PATTERN MAPPING TOOLS FOR ANALYSIS OF LAND USE-TRANSPORTATION INTERRELATIONSHIPS

### PRINCIPAL INVESTIGATOR

Jerry B. Schneider  
Departments of Urban Planning and Civil Engineering  
University of Washington  
133 More Hall  
Seattle, Washington 98195

### AMOUNT

1979 - \$85,100  
(\$6,431 in university funds)

### TENURE OF CONTRACT

May 1979 - July 1981

### MONITOR

Robert Dial, UTP-10  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9271

### ABSTRACT

Better tools for describing complex urban travel patterns are needed to aid the identification of land use-transportation interrelationships. In this project automated flow mapping technique is developed that will build upon the Vector Accumulator Program (VAP) concept. VAP converts a trip table into a flow map by connecting origin-destination pairs with vectors and accumulating them when they coincide. Improvements proposed include the ability to deal with natural and man-made barriers to travel, the introduction of the time dimension, and the addition of a trip direction capability. Alternative mapping techniques are investigated as well as the perceptual quality of each technique. The overall objective is to produce low-cost comprehensible maps of urban travel patterns to aid in understanding land use-transportation interrelationships.

### STATUS

As of June 1979, two software packages have been developed and tested in a preliminary. NETGRAF is associated with the NETSIM model and FREQGRAF is associated with the FREQ6PE model. Initial tests have produced good results in that higher performance solutions have been rather easily developed using the graphics as aids to

analysis and interpretation. Documentation of the two software packages is nearly complete and further tests are underway. A final report is expected to be available in October.

Phase I of this research has focused on designing, coding and testing a software package (FLOWGRAF), that is capable of accepting a set of time-specific, origin-destination data and producing three types of time-specific displays: a) many-to-many; b) many-to one (or one-to many); and c) direction-specific. These displays are based on a grid network, recognize natural and man-made barriers to travel, and accommodate differential speeds in the network, as they vary by region and time of day. After the trip volumes have been calculated by grid cell and accumulated, they are displayed using symbols or colors to represent various volumes of travel. A sequential series of these displays would then show how the travel pattern evolves over time. The FLOWGRAF system has been designed, coded and partially tested. Present activity is focused on testing and debugging the program. Phase II is the applications aspect of the project. The applications are designed to verify the reasonableness of FLOWGRAF's representation of travel patterns and to assess the comprehensibility of its displays to a wide variety of practitioners.

### APPLICATIONS

The addition of the computer graphics models developed under this contract to widely used freeway and urban street network models will allow State and local traffic engineers to visually observe the results of road modifications, signalization changes and construction restrictions on simulated traffic flow. Methods to increase system capacity can be directly observed through such displays and optimal solutions obtained in an interactive manner. The computer graphics package developed under this contract will be used by Federal planning officials and will also be disseminated by the Federal Highway Administration's Implementation Division to State and local traffic agencies.

When fully implemented, FLOWGRAF will be able to produce displays for any type of origin-destination data. Some diverse examples are bus transit patrons, airline passengers, goods movement, and recreation travel patterns. Origin-destination data are typically underanalyzed, and FLOWGRAF will make it much easier to comprehend the true nature of various types of travel patterns, as they vary in time and geographic space. By viewing these displays, transportation planners will be able to develop a better understanding of various travel patterns by being able to "see" them evolve; something no one has ever seen before.

**DEVELOPMENT OF URBAN FORM MEASURES TO AID POST-1980  
INVESTIGATIONS OF LAND USE, TRANSPORTATION, AND ENERGY  
INTERRELATIONSHIPS**

**PRINCIPAL INVESTIGATOR**

Jerry B. Schneider  
College of Architecture & Urban Planning;  
College of Engineering  
University of Washington  
133 More Hall (FX-10)  
Seattle, Washington 98195

**AMOUNT**

1980 - \$54,597  
(\$3,580 in university funds)

**TENURE OF CONTRACT**

September 1980 - June 1981

**MONITOR**

Robert B. Dial, UPM-20  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9271

**ABSTRACT**

Current concepts of land use transportation and energy relationships cannot be investigated due to a lack of useful and tested techniques for measuring urban form. This project will involve the development of a set of urban form measures. Tests will be conducted using data on the spatial distribution of population and jobs for 1960, 1970, and 1980 in several American cities. The urban form measures will be compared with various transportation system measures to identify macro-scale transportation-urban form relationships. A set of tested urban form measures suitable for use on a national basis will be recommended for implementation in the early 1980's.

## PARALLEL ALGORITHMS FOR LARGE SCALE NETWORK PROBLEMS

### PRINCIPAL INVESTIGATOR

Narsingh Deo  
Computer Science Department  
Washington State University  
Pullman, Washington 99164

### AMOUNT

1979 - \$34,975  
(\$12,739 in university funds)  
1980 - \$37,429  
(\$13,259 in university funds)

### TENURE OF CONTRACT

June 1979 - June 1981

### MONITOR

David I. Heimann, DTS-223  
U.S. Department of Transportation  
Transportation Systems Center  
Kendall Square  
Cambridge, MA 02142  
(617) 494-2749

### ABSTRACT

Since computer component speeds seem to be approaching some limit and the cost of hardware has been coming down rapidly, parallel processing is going to be increasingly commonplace. A major impediment to the use of parallelism is going to be the lack of algorithms that can exploit hardware parallelism efficiently by keeping all or most of processors busy simultaneously. One of the important application areas

where parallelism appears to hold a good deal of promise is solution of large scale network problems, but very little work has been done so far in this direction. The objective of this research is to design and analyze parallel algorithms for solving some of the important problems on very large scale networks which are vital both in transportation planning and traffic engineering.

### STATUS

Two very efficient and fast new parallel algorithms for shortest paths have been designed, coded, and run on an MIMD machine. These are a) Pape - D'Esopo version of the Moore's algorithm for finding shortest paths from one node to all others, and b) Warshall - Floyd algorithm for finding shortest paths between all pairs of nodes. More practical and fast parallel algorithms for other networks problems, e.g. minimum spanning tree and reliability—determination, are anticipated from upcoming research. Part of the Draft Phase Report was presented and published at the 1980 International Conference on Parallel Processing in August, 1980.

### APPLICATIONS

Once the parallel computers (MIMD type) become available commercially, the algorithms will be used widely. At present, parallel processors are only in prototype stage. Once they are commercially available, the superfast algorithms developed in this project will be used.

Denelcor, Inc. of Denver, Co. is providing a great deal of free computer time, and unlimited access to their prototype MIMD parallel computer called the HEP machine, which is being built for the U.S. Army's B.R.L. facility. Other potential users include Boeing, Floating-Point Systems, and several university research teams.

## THE INFLUENCE OF COAL TRANSPORT COSTS ON THE OPTIMAL DISTRIBUTION OF COAL AND THE OPTIMAL LOCATION OF ELECTRIC POWER GENERATING PLANTS

### PRINCIPAL INVESTIGATOR

Thomas C. Campbell  
Economics and Regional Research Institutes  
West Virginia University  
Morgantown, West Virginia 26506

### AMOUNT

1978 - \$46,765  
(\$2,927 in university funds)  
1979 - \$55,981  
(\$8,152 in university funds)

### TENURE OF CONTRACT

August 1978 - June 1980

### MONITOR

Byron Nupp, P-10  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-4447

### ABSTRACT

More coal moves on both railways and waterways than does any other commodity. As consumption increases, market patterns and the average distance coal is hauled will change significantly. This investigation attempts to define optimal regional coal markets that best serve the nation's rising energy needs. The analysis tests the thesis that real work conditions illustrated by spatial differentiation can be more thoroughly understood following careful theoretical generalization and empirical estimates. Changes in the pattern of coal utilization caused by the conversion from oil and natural gas to coal, along with the opening of the western coal deposits and the shifts in consumption to new areas and new users, will inevitably cause significant modifications in market area analysis

and in optimal coal-hauling patterns. Initial empirical results and model of this study have been revised and redefined on the basis of structural changes in demand and supply and the impact of location of electrical power generating plants, until optimal market patterns consistent with national energy policy have been obtained. By following the model, savings are possible in both transportation costs and energy consumption.

The research is a theoretical and empirical investigation of the impact of space on the movement of coal. Market area analysis was the first step, followed by the adjustment on the basis of structural changes and locational impact of power generating plants. After the completion of the basic evaluation, the final step was to determine current and future optimal utilization and distribution of coal among regions.

### STATUS

Both the theoretical market area analysis and the empirical investigation are complete. Two articles in professional journals based on the research were published. Completion of the final report is in progress.

### APPLICATIONS

With transportation being a large source of energy consumption because of the great tonnages and longer distance hauls, investigation relating to energy efficiency of coal transportation becomes increasingly critical. This study contributes to that effort. The results will be useful in planning and research by coal and utility industries, coal carriers, and Government agencies, particularly in planning and projecting transport needs, and determining from which regions the coal should be obtained for specific markets. The findings will also be useful for operations executives in formulation of plans for expansion of electric power generation capacity, and for determination of optimal supply sources of fuel for each plant.

The Department of Transportation, Office of Intermodal Studies expects to use the results in their coal transportation mandate policy issues analysis.

## SYNTHETIC TRAVEL FORECASTING USING TRAFFIC COUNT CORRELATIONS

### PRINCIPAL INVESTIGATOR

Edward S. Neumann  
Department of Civil Engineering  
West Virginia University  
Morgantown, West Virginia 26506

### AMOUNT

1979 - \$55,000  
(\$6,960 in university funds)

### TENURE OF CONTRACT

August 1979 - November 1980

### MONITOR

George E. Schoener, HHP-24  
Federal Highway Administration  
U.S. Department of Transportation  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-0150

### ABSTRACT

Traffic counts routinely taken on urban streets contain information that is not fully utilized in conventional travel forecasting procedures. Often collected at considerable expense, ways should be found to make better use of this data. The objective of this research is to develop and test statistical

methods for utilizing the traffic count data to improve the accuracy of existing travel forecasting methods. This research is relevant to cities of under 250,000 population, which may have limited money available for transportation planning studies.

### STATUS

This project has examined the feasibility of forming groups of traffic count stations in small to medium size cities, on the basis of similarity of hourly traffic volume patterns. Traffic count data for specific cities have been coded and keypunched. Using correlations of hourly volumes, links have been clustered for the cities. Regression equations have been developed to predict cluster membership. Regression analysis will then be used to examine the feasibility of extracting trip generation rates from traffic count data.

Traffic count and transportation forecasting data have been supplied by the Kentucky Department of Transportation, West Virginia Department of Highways, Virginia Department of Highways and Transportation, and Ohio Department of Transportation.

### APPLICATIONS

This research has potential use for making synthetic highway volume forecasts for small and medium size cities. It could reduce volume counting costs.

Quarterly progress reports have been transmitted to transportation planners in four states and to the Chairman of TRB Committee A1DO5, "Transportation Planning Needs and Requirements for Small and Medium Size Communities."

## PREDICTING PUBLIC RESPONSE TO PROSPECTIVE TRANSPORTATION POLICIES BASED ON THEIR STATED INTENTIONS

### PRINCIPAL INVESTIGATOR

Dennis H. Gensch  
School of Business Administration  
University of Wisconsin, Milwaukee  
Milwaukee, Wisconsin 53211

### AMOUNT

1978 - \$75,000  
(\$16,491 in university funds)

### TENURE OF CONTRACT

June 1978 - June 1980

### MONITOR

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U.S. Department of Transportation  
Transportations Systems Center  
Kendall Square  
Cambridge, Massachusetts  
(617) 494-2041

### ABSTRACT

Several market research studies have shown that, in some cases, consumers make decisions about product choice in a non-compensatory way; that is, they examine the features of a produce sequentially and eliminate products that fall outside the bounds of acceptability on that feature. The objective of this research is to develop and validate a non-compensatory model of how consumers make decisions among transportation alternatives. The model assumes that users make choices among systems by examining their features with a sequential non-compensatory process. The sequential model and a more traditional logit model have been applied to the survey data

previously collected before and after the Santa Monica Diamond Lane experiment. Predictions of mode use have been made from both models. Overall, the non-compensatory model predicts as well as the logit model; however, the two models work best for different segments of people. The models are being refined to increase their predictive power and then used to specify the conditions under which users actually carry out their intentions to switch modes. A computationally efficient computer program for construction of the sequential decision model from user feature ratings has been developed and will be included with the final report.

### STATUS

All of the research on this project has been completed, and the final report is currently being prepared. The research consisted of the segmentation and development of an exact aggregate hierarchical algorithm. This algorithm was empirically applied to the Santa Monica Data Set and showed substantial improvements in predictive ability in choice modeling over the current state-of-the-art.

Four articles pertaining to this research have been published in various academic journals, such as Management Science and Transportation Research.

### APPLICATIONS

The results of this research have attracted the attention of several government agencies, in particular, the National Science Foundation and the Department of Agriculture. These agencies will utilize the results to aid in determining why individuals make certain choices, for example choice of transportation modes. FHWA and UMTA will use study findings for alternative analysis. The results will assist decision-making on cost critical features of transportation plans.

## DEVELOPMENT OF PROCEDURES FOR IMPROVED UTILIZATION OF RESEARCH RESULTS IN URBAN TRANSPORTATION PLANNING

**PRINCIPAL INVESTIGATOR**

Edward A. Beimborn  
Center for Urban Transportation Studies  
University of Wisconsin, Milwaukee  
Milwaukee, Wisconsin 53201

**AMOUNT**

1979 - \$52,942  
(\$9,216 in university funds)

**TENURE OF CONTRACT**

September 1979 - August 1980

**MONITOR**

Granville Paules, UPM-20  
Urban Mass Transportation Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 426-9271

**ABSTRACT**

The objective of this research is to develop improved procedures for putting research results in urban transportation planning into practice. The research examines the barriers that exist to the widespread dissemination and implementation of innovative ideas in urban transportation, and develops techniques to overcome these barriers. The research is a joint effort of the Center for Urban Transportation Studies and the

Office of Statewide Transportation Programs, Division of Urban Outreach, University of Wisconsin-Milwaukee.

**STATUS**

Preliminary identification of barriers to research use has been completed. This included identifying the key innovations in transportation planning which appear to have a high potential but have not been implemented widely, (e.g. logit model-split modeling, traffic simulation programs, and TSM planning techniques). Also completed was a market analysis of the needs of users of urban transportation research. The project then developed alternative means to disseminate new research results. A list of over 30 techniques was developed and examined in terms of their relative costs and effectiveness. Key factors such as audience, permanence of material, urgency, and cost were used to describe each technique.

The current research involves developing a set of recommendations for the most desirable methods to deliver innovative techniques in urban transportation planning, which is done by reviewing alternative techniques that can be used to most effectively overcome the barriers to implementation at a reasonable cost.

**APPLICATION**

The recommendations developed in this research are expected to have an impact upon federal research management and dissemination. Programs at both the state and local level, as well as academic research programs, will be able to utilize these results.

## SHEAR STRENGTH CHARACTERISTICS OF SOILS SUBJECTED TO FROST ACTION

**PRINCIPAL INVESTIGATOR**

Joseph D. Sage  
Worcester Polytechnic Institute  
Institute Road  
Worcester, Massachusetts 01609

**AMOUNT**

1980 - \$78,910  
(\$4,155 in university funds)

**TENURE OF CONTRACT**

September 1980 - November 1981

**MONITOR**

Albert F. DiMillio, HRS-21  
Federal Highway Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590  
(202) 557-5216

**ABSTRACT**

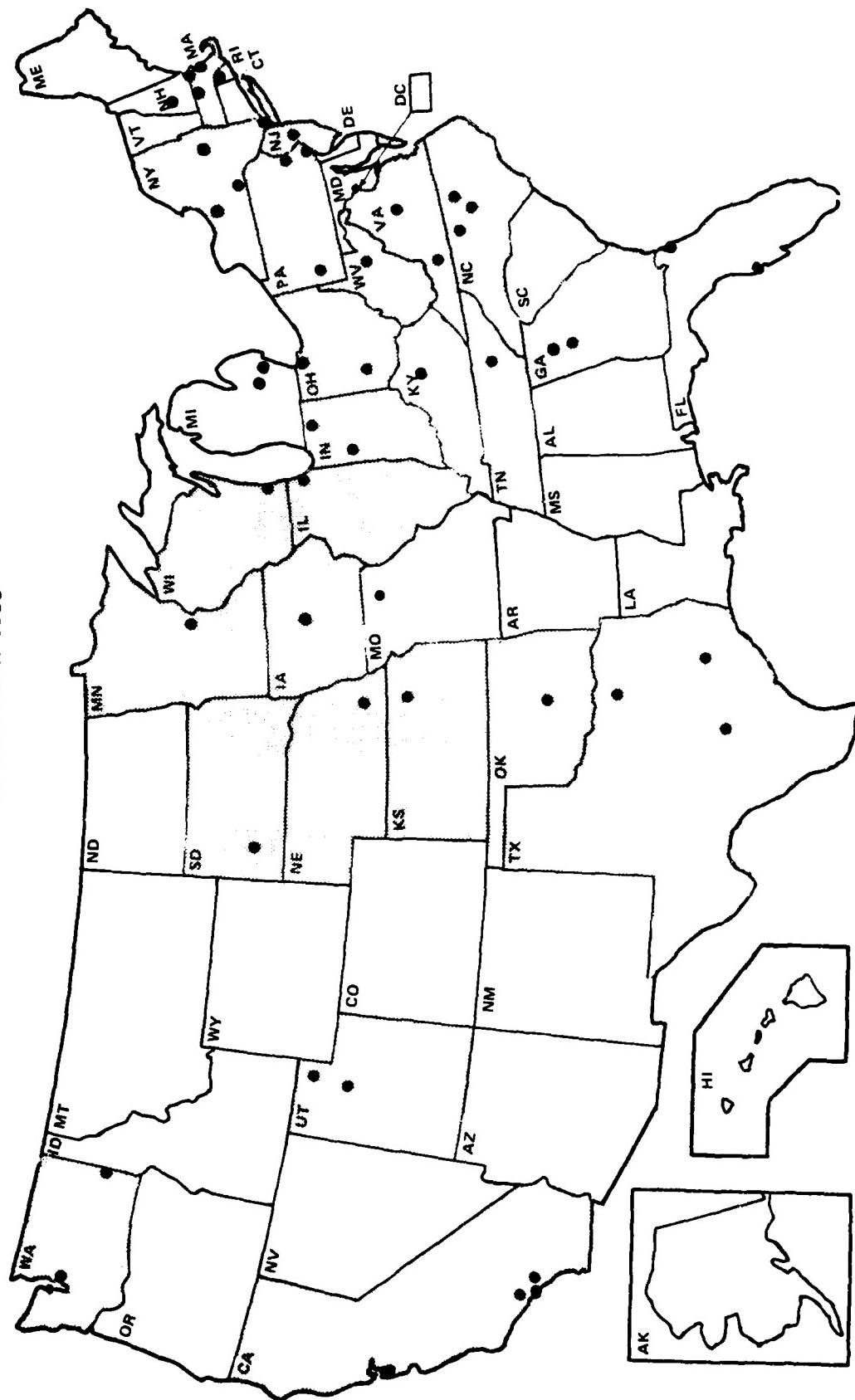
The object of this research is to develop an improved method for measuring the undrained shear strength of a thaw weakened soil. In addition, the mechanisms of moisture transfer will be studied to develop a prediction technique for determining the quantity and distribution of the migrating water. The effectiveness of filter fabrics for draining excess pore water pressures from zones of high water content will also be evaluated. A direct simple shear device will be designed and fabricated to accommodate a soil sample in which a representative thermal gradient and associated ice lensing may be established. Prior to the shear testing, the temperature in the soil sample will be gradually lowered in order to freeze the sample from the top downward, and water will be free to be drawn up to the advancing freezing front. The sample will then be allowed to thaw before the shear tests begin. The freezing, thawing, and shear testing will all be done inside a temperature control cabinet. Specific tests will be repeated under the additional conditions of horizontal strips of filter fabric within the soil sample. The shear test results on the thawed samples without filter fabric will be compared with pre-freeze strength values and thawed samples with filter fabric.

## **PART II**

# **FY 1980 Categorical Breakdowns**

**GEOGRAPHICAL DISTRIBUTION OF PROGRAM OF UNIVERSITY RESEARCH PROJECTS**

**FISCAL YEAR 1980**



● UNIVERSITY OF PUERTO RICO

**UNIVERSITIES LISTED ACCORDING TO STATE**  
**(Active Contracts, FY 1980)**

**ALASKA**

Alaska, Fairbanks

**CALIFORNIA**

California, Irvine  
California, Los Angeles  
Southern California Institute of Technology  
Stanford (2)

**DISTRICT OF COLUMBIA**

Howard

**FLORIDA**

North Florida & Edward Waters College

**GEORGIA**

Clark College  
Georgia Institute of Technology  
Georgia State

**ILLINOIS**

Northwestern (3)

**INDIANA**

Purdue  
Notre Dame

**IOWA**

Iowa  
Iowa State

**KANSAS**

Kansas State

**KENTUCKY**

Kentucky

**MARYLAND**

John Hopkins

**MASSACHUSETTS**

Lowell (2)  
Massachusetts, Amherst  
Massachusetts Institute of Technology (8)  
Worcester Polytechnic Institute

**MICHIGAN**

Michigan, Ann Arbor  
Michigan, Dearborn

**MINNESOTA**

Minnesota (3)

**NEBRASKA**

Nebraska, Lincoln (2)

**NEW HAMPSHIRE**

Dartmouth College

**NEW JERSEY**

Princeton (6)  
Rutgers

**NEW YORK**

Cornell (2)  
New York, Polytechnic Institute of (3)  
New York, State, at Binghamton  
New York, State, at Buffalo  
Rensselaer Polytechnic Institute (2)

**NORTH CAROLINA**

North Carolina  
North Carolina A&T State  
North Carolina Central  
Shaw

**OHIO**

Bowling Green State (2)  
Central State

**OKLAHOMA**

Oklahoma

**PENNSYLVANIA**

Lehigh  
Pennsylvania (4)  
Pennsylvania State  
Pittsburgh (2)

**RHODE ISLAND**

Brown (2)

**SOUTH DAKOTA**

South Dakota School of Mines & Tech. (2)

**TEXAS**

Texas, Austin (2)  
Texas, Dallas  
Texas A&M (3)

**UNIVERSITIES LISTED ACCORDING TO STATE**  
**(Active Contracts, FY 1980)**

**UTAH**

Utah  
Utah State

**VIRGINIA**

Virginia (3)  
Virginia Polytechnic Institute & State  
Virginia State College

**WASHINGTON**

Washington (2)  
Washington State

**WEST VIRGINIA**

West Virginia (2)

**WISCONSIN**

Wisconsin, Milwaukee (2)

**PUERTO RICO**

Puerto Rico, Mayaguez

**UNIVERSITIES LISTED ACCORDING TO CONTRACT NUMBER**  
**(Active Contracts, FY 1980)**

Contract Number	University	Contract Number	University
DOT-OS-40008	Alaska, Fairbanks	DOT-RC-92010	California, Irvine
DOT-OS-50233	Virginia	DOT-RC-92011	Central State
DOT-OS-60174	Utah	DOT-RC-92012	Iowa State
DOT-OS-70052	Massachusetts Institute of Technology	DOT-RC-92013	Kansas State
DOT-OS-70053	Massachusetts Institute of Technology	DOT-RC-92014	Lowell
DOT-OS-70054	Massachusetts Institute of Technology	DOT-RC-92015	Lowell
DOT-OS-70058	New York, State, at Buffalo	DOT-RC-92016	Massachusetts Institute of Technology
DOT-OS-70061	Northwestern	DOT-RC-92017	Massachusetts Institute of Technology
DOT-OS-70067	Princeton	DOT-RC-92018	Minnesota
DOT-OS-70072	South Dakota School of Mines & Technology	DOT-RC-92019	Minnesota
DOT-OS-70074	Texas, Austin	DOT-RC-92020	Nebraska, Lincoln
DOT-OS-80005	Howard	DOT-RC-92021	Nebraska, Lincoln
DOT-OS-80008	Princeton	DOT-RC-92022	New York, Polytechnic Institute
DOT-OS-80013	Virginia Polytechnic Institute & State	DOT-RC-92023	New York, Polytechnic Institute
DOT-RC-82004	Georgia State	DOT-RC-92024	New York, State, Binghamton
DOT-RC-82005	John Hopkins	DOT-RC-92025	North Carolina
DOT-RC-82007	Lehigh	DOT-RC-92026	North Carolina A&T State
DOT-RC-82008	Minnesota	DOT-RC-92027	North Carolina Central
DOT-RC-82010	Notre Dame	DOT-RC-92028	Northwestern
DOT-RC-82012	Pennsylvania	DOT-RC-92029	Oklahoma
DOT-RC-82013	Pennsylvania	DOT-RC-92030	Pennsylvania
DOT-RC-82014	Princeton	DOT-RC-92031	Pittsburgh
DOT-RC-82015	Bowling Green State	DOT-RC-92032	Princeton
DOT-RC-82016	Rensselaer Polytechnic Institute	DOT-RC-92033	Princeton
DOT-RC-82017	Shaw	DOT-RC-92034	Purdue
DOT-RC-82018	Utah State	DOT-RC-92035	South Dakota School of Mines & Technology
DOT-RC-82019	Virginia	DOT-RC-92036	South California
DOT-RC-82020	Virginia State College	DOT-RC-92037	Texas A&M
DOT-RC-82023	Wisconsin, Milwaukee	DOT-RC-92038	Texas A&M
DOT-RC-82026	Princeton	DOT-RC-92039	Texas, Austin
DOT-RC-82028	Massachusetts, Amherst	DOT-RC-92040	Texas, Dallas
DOT-RC-82029	Iowa	DOT-RC-92041	Washington
DOT-RC-82030	Pennsylvania State	DOT-RC-92042	Washington State
DOT-RC-82031	West Virginia	DOT-RC-92043	West Virginia
		DOT-RC-92044	Wisconsin, Milwaukee

**UNIVERSITIES LISTED ACCORDING TO CONTRACT NUMBER**  
**(Contracts Awarded FY 1980) continued**

Contract Number	University	Contract Number	University
DT-RS-56-80C-00006	Bowling Green State	DT-RS-56-80C-00021	Michigan, Dearborn
DT-RS-56-80C-00007	Brown	DT-RS-56-80C-00022	New York, Polytechnic
DT-RS-56-80C-00008	Brown		Institute of
DT-RS-56-80C-00009	California, Los Angeles	DT-RS-56-80C-00023	North Florida & Edwards
DT-RS-56-80C-00010	California Institute of Technology	DT-RS-56-80C-00024	Water College
DT-RS-56-80C-00011	Clark College	DT-RS-56-80C-00025	Northwestern
DT-RS-56-80C-00012	Cornell	DT-RS-56-80C-00026	Pennsylvania
DT-RS-56-80C-00013	Cornell	DT-RS-56-80C-00027	Pittsburgh
DT-RS-56-80C-00014	Dartmouth College	DT-RS-56-80C-00028	Puerto Rico, Mayaguez
DT-RS-56-80C-00015	Georgia Institute of Technology	DT-RS-56-80C-00029	Rensselaer Polytechnic Institute
DT-RS-56-80C-00016	Kentucky	DT-RS-56-80C-00030	Rutgers
DT-RS-56-80C-00017	Massachusetts Institute of Technology	DT-RS-56-80C-00031	Stanford
DT-RS-56-80C-00018	Massachusetts Institute of Technology	DT-RS-56-80C-00032	Stanford
DT-RS-56-80C-00019	Massachusetts Institute of Technology	DT-RS-56-80C-00033	Texas A&M
DT-RS-56-80C-00020	Michigan, Ann Arbor	DT-RS-56-80C-00034	Virginia
		DT-RS-56-80C-00035	Washington
			Worcester Polytechnic Institute

**MINORITY SCHOOLS  
PARTICIPATING IN THE PROGRAM OF UNIVERSITY RESEARCH  
FY 1980**

<b>University</b>	<b>Contract Number</b>	<b>Page</b>
<b>Central State University Wilberforce, OH</b>	<b>DOT-RC-92011</b>	<b>11</b>
<b>Clark College Atlanta, GA</b>	<b>DT-RS-56-80C-00011</b>	<b>12</b>
<b>Howard University Washington, D.C.</b>	<b>DOT-OS-80005</b>	<b>18</b>
<b>North Carolina A&amp;T State University Greensboro, NC</b>	<b>DOT-RC-92026</b>	<b>50</b>
<b>North Carolina Central University Durham, NC</b>	<b>DOT-RC-92027</b>	<b>51</b>
<b>University of North Florida &amp; Edward Waters College Jacksonville, FL</b>	<b>DT-RS-56-80C-00023</b>	<b>52</b>
<b>University of Puerto Rico, Mayaguez Mayaguez, Puerto Rico</b>	<b>DT-RS-56-80C-00027</b>	<b>71</b>
<b>Shaw University Raleigh, NC</b>	<b>DOT-RC-82017</b>	<b>76</b>
<b>Virginia State College Petersburg, VA</b>	<b>DOT-RC-82020</b>	<b>95</b>

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## I. AUTOMOTIVE VEHICLE AND MATERIALS TECHNOLOGY

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1. UNIVERSITY OF CALIFORNIA, LOS ANGELES Research Studies Pertaining to Hydrogen Car Development	DOT-OS-40111	*
2. CORNELL UNIVERSITY Combustion in Hydrogen-Fueled-Transportation Systems	DOT-OS-30113	*
3. GEORGIA INSTITUTE OF TECHNOLOGY Fundamental Studies in Tribology as Related To Automotive Fuel Economy	DT-RS-56-80C-00015	
4. UNIVERSITY OF ILLINOIS, URBANA Full Scale Vehicle Drag Component Evaluation by Coast-Down Testing on Level and Inclined Roads and Tracks	DOT-OS-60132	*
5. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Development of the Valved Hot-Gas Engine	DOT-OS-40086	*
6. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Modelling and Dynamic Control of Internal Combustion Engines	DOT-RC-92017	
7. UNIVERSITY OF MICHIGAN, ANN ARBOR Physical Property of Fuel/Water Emulsions	DT-OS-70056	*
8. UNIVERSITY OF MICHIGAN, DEARBORN A Study of Diesel Spray Characteristics at High Injection Pressures	DT-RS-56-80C-00021	
9. UNIVERSITY OF OKLAHOMA Combustion of Fuel-Water Emulsions in Diesel Engines	DOT-RC-82001	*
10. PENNSYLVANIA STATE UNIVERSITY Objective Measures of Ride Quality	DOT-OS-40010	*
11. PRINCETON UNIVERSITY Evaluation of Achievable Internal Combustion Engine Economy and Emissions Performance by Improved Engine Control	DOT-OS-70067	
12. RICE UNIVERSITY Flammability Studies and Toxicological Evaluation of Materials Used in Transportation Vehicles	DOT-OS-60149	*
13. RUTGERS UNIVERSITY A Study of Particulate Formation and Radiant Heat Loss in Direct Injection-Type Diesel Engines	DT-RS-56-80C-00029	
14. STANFORD UNIVERSITY Closed-Loop Control for Internal Combustion Exhaust Emissions	DOT-OS-30111	*
15. STANFORD UNIVERSITY Closed Loop Control of Automotive Engines	DOT-OS-60151	*

\* Contracts not active in FY 1980; project completed.

16. STANFORD UNIVERSITY Air-Fuel Mixture Sensing and Control in Automotive Engines	DT-RS-56-80C-00030
17. STANFORD UNIVERSITY Development of Ultrahigh Carbon (UHC) Steels for Automotive Applications	DT-RS-56-80C-00031
18. UNIVERSITY OF TEXAS-ARLINGTON An Investigation of an Air-Modulated Fluidic Fuel Injection System	DOT-OS-60152
19. UNIVERSITY OF TEXAS, AUSTIN Transportation to Fulfill Human Needs in the Rural/Urban Environment-Automobile Ride-Quality Evaluation	DOS-OS-60125
20. UNIVERSITY OF UTAH Evaluating Combustion Product Toxicity and Smoke from Burning Transportation Vehicle Interior Materials	DOT-OS-60174
21. UNIVERSITY OF WISCONSIN, MADISON Flywheel Energy Management Systems for Improving the Fuel Economy of Motor Vehicles	DOT-OS-60177

## II. ENERGY EFFICIENCY AND MANAGEMENT

	<b>Contract No.</b>
1. CARNEGIE-MELLON UNIVERSITY Energy Management for Electric-Powered Transportation Services	DOT-OS-60129
2. DARTMOUTH COLLEGE Interactions Between National Energy Supply and Transportation- Related Energy Consumption	DOT-RC-82003
3. NORTHWESTERN UNIVERSITY Transportation Energy Consumption and Urban Form Relationship	DOT-OS-50118
4. WEST VIRGINIA UNIVERSITY The Influence of Coal Transport Costs on the Optimal Distribution of Coal and the Optimal Location of Power Generating Plants	DOT-RC-82031
5. UNIVERSITY OF WISCONSIN, MADISON Increased Fuel Economy in Transportation Systems by Use of Energy Management	DOT-OS-30112

## III. FREIGHT MOVEMENT

	<b>Contract No.</b>
1. IOWA STATE UNIVERSITY Integrated Analysis of Small Cities Intercity Transportation to Facilitate the Achievement of Regional Goods	DOT-OS-30106
2. MASSACHUSETTS INSTITUTE OF TECHNOLOGY A Multi-Regional Input-Output (MRIO) Study of Commodity Freight Shipments	DOT-OS-30104
3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Analysis of Freight Markets	DOT-OS-50112

4. UNIVERSITY OF PENNSYLVANIA Transport of Solid Commodities via Freight Pipeline	DOT-OS-50119	*
5. UNIVERSITY OF PENNSYLVANIA International Symposium on Freight Pipeline	DOT-OS-60143	*
6. UNIVERSITY OF PENNSYLVANIA The Augmentation of Freight Transportation Data Sets	DT-RS-56-80C-00025	
7. PENNSYLVANIA STATE UNIVERSITY An Experiment in Freight Modal Choice Delineating the Rail-Truck Interface	DOT-OS-50119	*
8. UTAH STATE UNIVERSITY Freight Rate Structure Study	DOT-OS-30116	*

#### IV. GENERAL TRAVEL BEHAVIOR

	<b>Contract No.</b>	
1. BROWN UNIVERSITY Community Development and Changing Travel Patterns	DT-RS-56-80C-00008	
2. UNIVERSITY OF CALIFORNIA, IRVINE Economic Structure, Community Development, and Transportation Systems: An Empirical Analysis of Household Activity Patterns	DOT-RC-92010	
3. CHICAGO STATE UNIVERSITY Declining Mass Transportation Fear, and the Journey to Work	DOT-OS-40082	*
4. HOWARD UNIVERSITY Survey of Black Single-Parent Family Transportation Needs	DOT-OS-80005	
5. UNIVERSITY OF ILLINOIS/Chicago Circle Conference for Applying Behavioral Science to Transportation Policy, Planning and Programming	DOT-OS-70048	*
6. NORTH CAROLINA CENTRAL UNIVERSITY The Equity and Adequacy of Transportation Facilities in Black Communities: The Problem of Residence-Shopping Place Separation	DOT-RC-92027	
7. NORTHWESTERN UNIVERSITY A Method for Assessing Pricing and Structural Changes on Transport Mode Use	DOT-OS-40001	*
8. UNIVERSITY OF TEXAS, AUSTIN Transportation to Fulfill Human Needs in the Rural/Urban Environment	DOT-OS-30093	*
9. TUFTS UNIVERSITY Impacts of Tourist Transportation and People Overloads on National Historic and Scenic Monuments and Strategies for their Resolution	DOT-OS-50045	*
10. UNIVERSITY OF WASHINGTON Development of Improved Urban Travel Pattern Mapping Tools for Analysis of Land-Use/Transportation Interrelationships	DOT-RC-92041	

**11. UNIVERSITY OF WASHINGTON** DT-RS-56-80C-00034  
Development of Urban Form Measures to Aid Post-1980 Investigations  
of Land Use—Transportation—Energy Interrelationships

**V. HAZARDOUS MATERIALS/ENVIRONMENTAL/MATERIAL TRANSPORTATION EMERGENCIES**

	<b>Contract No.</b>	
<b>1. UNIVERSITY OF ARKANSAS</b> Spill of Soluble, High Density, Immiscible Chemicals on Water	DOT-OS-70040	*
<b>2. ARIZONA STATE UNIVERSITY</b> Spatial and Temporal Resolutions of Urban Air Pollution Models for Evaluation of Transportation Strategies in Phoenix, Arizona	DOT-OS-60127	*
<b>3. CENTRAL STATE UNIVERSITY</b> Microencapsulation for Transportation Safety	DOT-RC-92011	
<b>4. KANSAS CITY UNIVERSITY</b> A Community Model for Handling Hazardous Materials Transportation Emergencies	DOT-RC-92013	
<b>5. LOWELL TECHNOLOGICAL INSTITUTE</b> Spills of Hazardous Chemicals on Waterways	DOS-OS-30109	*
<b>6. UNIVERSITY OF MAINE</b> Electrical Properties of Ice-Solid Interfaces	DOT-OS-70050	*
<b>7. UNIVERSITY OF MISSOURI, ROLLA</b> The Measurement and Identification of Ultrafine Aerosols in Polluted Air	DOT-RC-82009	*
<b>8. NEW YORK, POLYTECHNIC INSTITUTE OF</b> Seminar on Polymeric Materials and their Use in Transportation	DOT-OS-60139	*
<b>9. UNIVERSITY OF NOTRE DAME</b> A Combined Experimental and Analytical Investigation of the Influence of Low Level Wind Shear on the Handling Characteristics of Aircraft	DOT-RC-82010	
<b>10. NORTH CAROLINA STATE UNIVERSITY</b> An Ecological System Approach to Community Noise Abatement	DOT-OS-30102	*
<b>11. UNIVERSITY OF OKLAHOMA</b> Environmental Protection During and Following Transportation Accidents/Emergencies	DOT-RC-92029	
<b>12. PENNSYLVANIA STATE UNIVERSITY</b> The Effects of Mobile Source and Aircraft Noise and Air Pollutants on Residential Property Values	DOT-OS-40094	
<b>13. PENNSYLVANIA STATE UNIVERSITY</b> Aircraft Noise Abatement Benefits—Theory and Measurement	DOS-OS-70066	*
<b>14. RENSSELAER POLYTECHNIC INSTITUTE</b> Relationship Between Specific Non-Methane Hydrocarbons and Ozone in Ambient Air and Their Role in Transportation Control Strategies	DOT-OS-70070	*

15. SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY Investigation of the Basic Forces Involved in the Adhesion of Ice to Highway Surface	DOT-OS-70072
16. UNIVERSITY OF SOUTHERN CALIFORNIA Study of the Capability of Risk Analysis for the Support of the Formulation of Regulations for the Transportation of Hazardous Materials	DOT-RC-92036
17. UNIVERSITY OF TEXAS, AUSTIN Vehicle Noise Studies	DOT-OS-30089
18. TEXAS A&M UNIVERSITY A Nonlinear Analysis of Liquid Sloshing in Rigid Containers	DOT-RC-92037
19. VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY A Study of Lead, Cadmium, Nickel and Zinc Levels in Soil, Vegetation, Invertebrates and Mammals Associated with Highways of Different Traffic Densities	DOT-OS-60175
20. WORCESTER POLYTECHNIC INSTITUTE Shear Strength Characteristics of Soils Subjected to Frost Action	DT-RS-56-80C-00035

#### **VI. HIGHWAY AND STRUCTURES MAINTENANCE**

	Contract No.
1. GEORGIA INSTITUTE OF TECHNOLOGY Low Cost Bicycle Path Pavements	DOT-OS-50226
2. UNIVERSITY OF ILLINOIS, CHICAGO CIRCLE An Integrated Engineering—Preservation, Improvement and Replacement of Elevated Transportation Structures	DOT-OS-30092
3. IOWA STATE UNIVERSITY Geophysical Grouting Control System	DOT-RC-92012
4. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Development of Quality Standards and Impact Models for Highway Maintenance	DOT-RC-92016
5. UNIVERSITY OF NEBRASKA, LINCOLN Cost-Effectiveness of Retrofitting Concrete Median Barriers	DOT-RC-92021
6. PENNSYLVANIA STATE UNIVERSITY Advanced Technology Materials Applied to Guideways, Highways, and Airport Runways	DOT-OS-40009
7. PENNSYLVANIA STATE UNIVERSITY Fingerprinting Versus Field Performance of Paving Grade Asphalts	DOT-RC-82030
8. PURDUE UNIVERSITY Non-Destructive Determination of Residual Service Life of Bridge Structures	DOT-RC-92034
9. SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY Superplasticized Concretes for Rehabilitation of Bridge Decks and Highway Pavements	DOT-RC-92035

## VII. LABOR-MANAGEMENT RELATIONS

	<b>Contract No.</b>
1. UNIVERSITY OF CALIFORNIA, IRVINE The Impact of Union-Management Relations on Productivity and Efficiency in Urban Mass Transit	DOT-OS-70042
2. UNIVERSITY OF CALIFORNIA, IRVINE The Impact of Labor-Management Relations on Productivity and Efficiency in Urban Mass Transit	DOT-RC-82002
3. UNIVERSITY OF NORTH FLORIDA Study of Unions, Management Rights, and the Public Interest in Mass Transit	DOT-OS-50116

## VIII. LAND/USE/ECONOMIC IMPACTS OF TRANSPORTATION

	<b>Contract No.</b>
1. COLORADO STATE UNIVERSITY Secondary Impacts and Consequences of Highway Projects	DOT-OS-50043
2. UNIVERSITY OF IOWA Re-Use Planning of Transportation Property Abandonments	DOT-OS-40019
3. JOHN HOPKINS UNIVERSITY An Analysis of Transportation/Land Use Interactions	DOS-RC-82005
4. UNIVERSITY OF KENTUCKY An Elusive Dimension of the Urban Transportation Problem: The Land Use-Transportation Interface	DOT-OS-50111
5. UNIVERSITY OF MARYLAND The Development and Testing of Indicators of Neighborhood Cohesion and Other Social Characteristics for Assessing and Predicting Transportation Impacts on Neighborhoods	DOT-OS-70051
6. UNIVERSITY OF MINNESOTA Analyzing the Impacts of Transportation Policies on Rural Mobility and Economic Development	DOT-RC-92019
7. NORTHWESTERN UNIVERSITY Effects of Transportation on the Tax Base and Development of Cities	DOT-RC-92028
8. UNIVERSITY OF PENNSYLVANIA A Case Study of the 1977 Expansion of the Philadelphia Commercial Zone	DOT-RC-82013
9. PRINCETON UNIVERSITY Alternative Policies for Implementing Transit Corridor Land-Use Management and Development	DOT-OS-80008
10. RENSSELAER POLYTECHNIC INSTITUTE Development of a Normative Method to Plan Urban Structure Considering Spatial and Temporal Interaction Among Transportation, Population and Employment/Public Facilities.	DOT-RC-82016

<b>11. SOUTHERN UNIVERSITY</b>	<b>DOT-OS-30094</b>
A Measurement of Highway Induced Changes in Land Use, Population Density, and Minority Recreational Opportunities	
<b>12. STATE UNIVERSITY OF NEW YORK, BINGHAMTON</b>	<b>DOT-RC-92024</b>
Impact of Transportation Policy on the Spatial Distribution of Retail Activity	
<b>13. UNIVERSITY OF TEXAS AT DALLAS</b>	<b>DOT-RC-92040</b>
The Impact of the Interstate Highway System on Non-Metropolitan Growth	
<b>14. TEXAS A&amp;M UNIVERSITY</b>	<b>DOT-RC-92038</b>
The Impact of Technological Changes in Transportation Networks on Productivity and Development	

#### **IX. MARINE STUDIES/COASTAL ZONE MANAGEMENT/PORT PLANNING AND DEVELOPMENT**

	<b>Contract No.</b>
<b>1. CARNEGIE-MELLON UNIVERSITY</b>	DOT-OS-70080
Marine Safety and Environmental Control: An Economic Analysis	
<b>2. MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>	DOT-OS-40004
Utilizing the Existing Regulatory Structure to Influence Port Development	
<b>3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>	DOT-OS-60138
Offshore Liquified Natural Gas Terminals	
<b>4. OLD DOMINION UNIVERSITY</b>	DOT-OS-70063
Transportation Impacts and Coastal Zone Management	
<b>5. PRINCETON UNIVERSITY</b>	DOT-RC-82014
Developing a Coordinated Transportation Planning Process for Coastal Zone Management	
<b>6. UNIVERSITY OF WISCONSIN, MILWAUKEE</b>	DOT-OS-30090
Seminar on Port Planning and Development as Related to Problems of U.S. Ports and U.S. Coastal Environment	

#### **X. PARATRANSIT/RIDE SHARING**

	<b>Contract No.</b>
<b>1. UNIVERSITY OF CALIFORNIA/BERKELEY</b>	DOT-OS-50237
Alternative Roles for Personal Transportation	
<b>2. CARNEGIE-MELLON UNIVERSITY</b>	DOT-OS-40081
Ride Sharing Paratransit Experiments	
<b>3. UNIVERSITY OF COLORADO</b>	DOT-OS-50225
Seminar on Personal Rapid Transit	
<b>4. UNIVERSITY OF ILLINOIS, CHICAGO CIRCLE</b>	DOT-OS-60131
Formulation of Conventional and Paratransit Policy Recommendations for Low Density Areas: A Study of Metropolitan Chicago	

5. PENNSYLVANIA STATE UNIVERSITY/MIDDLETON Economic Analysis of the Taxicab Industry in Pennsylvania: Demand and Cost	DOT-OS-30105
6. UNIVERSITY OF PITTSBURGH Alternative Roles of the Automobile	DOT-OS-50242
7. STEVENS INSTITUTE OF TECHNOLOGY A Publico System for Highly Congested Urban Areas	DOT-OS-50231
8. UNIVERSITY OF TENNESSEE Development of a Strategy for Successful Commuter Pools in Urban Areas	DOT-OS-40096
9. UNIVERSITY OF TENNESSEE Developing Alternatives to Resolve the Evolving Insurance Dilemma for Operators of High Occupancy Vehicles	DOT-OS-70073

#### **XI. RAIL/GUIDEWAY/PIPELINE TECHNOLOGY AND FLAW DETECTOR**

	Contract No.
1. UNIVERSITY OF ALABAMA Applications of Disturbance Accommodating Control Theory to Vehicle Active Ride Control Problems	DOT-OS-60126
2. UNIVERSITY OF CALIFORNIA, LOS ANGELES Nondestructive Evaluation of Longitudinal Rail Force by Acoustic Emission Method	DT-RS-56-80C-00009
3. CORNELL UNIVERSITY Infrared Techniques in Magnetic Levitation and Propulsion Guideway Design	DOT-OS-70045
4. DUKE UNIVERSITY Dynamic Experiments of Alternative Guideway-Vehicle Systems	DOT-OS-60130
5. JOHN HOPKINS UNIVERSITY Comparison Between X-Ray Diffraction and Ultrasonic Non-Destructive Evaluations of Residual Stress in Structural Materials	DOT-RC-82006
6. LEHIGH UNIVERSITY Fracture Analysis of Pipelines	DOT-RC-82007
7. UNIVERSITY OF LOWELL Reliability of Ultrasonic Weld Interrogation Method	DOT-RC-92014
8. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Assessment of Technology Base and Applied Research for Non-Contacting Vehicle Suspension and Propulsion Systems	DOT-OS-60135
9. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Performance Limits of Rail Passenger Vehicles: Evaluation and Optimization	DOT-OS-70052
10. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Application of Active and Passive Suspension Techniques to Improve High Speed Ground Vehicle Performance	DT-RS-56-80C-00018

11. NEW YORK, POLYTECHNIC INSTITUTE OF	DOT-RC-92022	
Development of Improved Analytical Techniques for the Design of Three-Phase Traction Motors		
12. NEW YORK, STATE UNIVERSITY, BUFFALO	DOT-OS-70058	
A Theory for Track Maintenance Life Prediction		
13. UNIVERSITY OF OKLAHOMA	DOT-OS-40091	*
Non-Destructive Measurement of Longitudinal Rail Stresses		
14. UNIVERSITY OF PENNSYLVANIA	DOT-OS-40093	*
Improved Wheel and Rail Performance Control of Contact Stress		
15. UNIVERSITY OF PENNSYLVANIA	DOT-OS-60144	*
Fundamental Studies of Phenomena Related to Wheel-Rail Contact Stresses		
16. PRINCETON UNIVERSITY	DOT-OS-60147	*
Experimental Research on Rail Vehicle Safety Using Dynamically Scaled Models		
17. PRINCETON UNIVERSITY	DOT-RC-82026	
Longitudinal Control to Improve Performance, Reliability, and Safety in Automated Vehicle Systems		
18. PRINCETON UNIVERSITY	DOT-RC-92032	
Lateral Stability and Dynamic Response of Ram Air Cushion Vehicles		
19. PRINCETON UNIVERSITY	DOT-RC-92033	
Improvement in Rail Vehicle Dynamic Performance through Control of Linear Motor Lateral and Normal Forces		
20. UNIVERSITY OF TEXAS, AUSTIN	DOT-OS-50126	*
Ride Quality Studies on Ground-Based Transportation Systems		
21. UNIVERSITY OF TEXAS, AUSTIN	DOT-OS-70075	
Ride Quality Studies in Rubber-Tired Automated Guideway Transit Systems		
22. TEXAS A&M UNIVERSITY	DT-RS-56-80C-00032	
Optimization Study for Ultrasonic Flaw Detection in Railroad Rail		
23. UNIVERSITY OF VIRGINIA	DOT-RC-82019	
Limiting Performance Approach to Systems Design		
24. UNIVERSITY OF VIRGINIA	DT-RS-56-80C-00033	
Application of Image Processing to Vehicle Guidance and Safety		
25. VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY	DOT-OS-80013	
Interaction and Load Transfer Through Track-Guideway Systems		
26. WASHINGTON UNIVERSITY, ST. LOUIS	DOT-OS-30108	*
Advanced Design Technology for Rail Transportation Vehicles		

## XII. RAIL OPERATIONS AND NETWORKS

	<b>Contract No.</b>	
1. ARIZONA STATE UNIVERSITY Guideway Vehicle Cost Reduction	DOT-OS-50107	*
2. CORNELL UNIVERSITY Management of Railroad Car Distribution	DT-RS-56-80C-00013	
3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Methodologies for Developing and Evaluating Effective Railroad Networks	DOT-OS-40002	*
4. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Strategies for Improving Rail Car Distribution: A Study of Overcoming Organizational and Institutional Barriers to Innovation	DT-RS-56-80C-00019	
5. NORTHWESTERN UNIVERSITY Development of Hybrid Cost Functions from Engineering and Statistical Techniques: The Case of Rail	DOT-OS-70061	
6. PRINCETON UNIVERSITY Re-establishing Rail Service in Conjunction with New Feeder Systems	DOT-OS-40095	*
7. UNIVERSITY OF TENNESSEE Developing Local Strategies as Alternatives to Abandonment of Light Density Rail Lines	DOT-OS-50125	*
8. UNION COLLEGE Intercity Rail Energy Efficiency for Passenger and Freight Movement	DOT-OS-60124	*

## XIII. REGULATORY REFORM IMPACTS

	<b>Contract No.</b>	
1. BOSTON COLLEGE Quality of Service and Regulation in Air Passenger Transport	DOT-OS-70041	*
2. BOWLING GREEN STATE UNIVERSITY Utilization of ICC Operating Rights to Evaluate the Impact of ICC Regulations	DOT-RC-82015	
3. UNIVERSITY OF NORTH CAROLINA Economics of Scale in the U.S. Intercity Bus Industry	DOT-RC-92025	
4. UNIVERSITY OF NORTH FLORIDA & EDWARD WATERS COLLEGE Minority Participation in the Regulated Motor Carrier Industry	DT-RS-56-80C-00023	
5. OREGON STATE UNIVERSITY The Energy, Economic and Environmental Consequences of Oversized, Overweight Vehicles	DOT-OS-60142	*
6. UNIVERSITY OF PENNSYLVANIA An Examination of the Unregulated Trucking Experiences in New Jersey	DOT-OS-70064	*
7. UNIVERSITY OF PENNSYLVANIA An Examination of the Unregulated Trucking Experience in Delaware	DOT-RC-82012	

8. PURDUE UNIVERSITY	DOT-OS-70069
The Impact of Federal Trucking Regulation on Service to Small Communities	
9. VIRGINIA STATE COLLEGE	DOT-RC-82020
Socio-Economic Impact of Intra-State Motor Carrier Regulations on Rural Development in South Central Virginia	

10. WASHINGTON STATE UNIVERSITY	DOT-RC-82022
Common Carrier Obligations and the Provision of Freight Transport Service to Small Rural Communities.	

#### **XIV. RURAL TRANSPORTATION SYSTEMS/RURAL TRANSIT**

	Contract No.
1. UNIVERSITY OF ALASKA, FAIRBANKS	DOT-OS-40008
Transportation System Development for Alaska	
2. CLARION STATE COLLEGE	DOT-OS-30107
The Economic, Social, and Physical Impact of Rural Transportation in Venango County	
3. DARMOUTH COLLEGE	DOT-OS-80006
Techniques for Analyzing the Productivity and Efficiency of Rural Transit Systems	
4. GEORGE WASHINGTON UNIVERSITY	DOT-OS-30122
Revitalization of Small Communities through Transportation Options	
5. GEORGIA STATE UNIVERSITY	DOT-RC-82004
An Evaluation of Potential Ability of Geographically Based Shippers' Cooperative Associations to Provide Benefits to Shippers in Low Traffic Density (Non-Central, Non-Dynamic) Areas of the United States	
6. UNIVERSITY OF MASSACHUSETTS, AMHERST	DOT-RC-82028
Assessing Local Deficit and Social Service Agency User Charges for Rural Public Transportation	
7. MICHIGAN STATE UNIVERSITY	DOT-OS-50044
Transportation Investment Requirements and Growth Patterns in Michigan	
8. NORTH CAROLINA A&T STATE UNIVERSITY	DOT-OS-40005
Rural Transportation Feasibility Study	
9. NORTH CAROLINA A&T STATE UNIVERSITY	DOT-OS-50115
Evaluating Rural Public Transportation Demonstrations	
10. NORTH CAROLINA A&T STATE UNIVERSITY	DOT-OS-80007
An Analysis of Shipper/Receiver Transportation Mode Choice in Selected Rural Communities	
11. SOUTH DAKOTA STATE UNIVERSITY	DOT-OS-50229
A Pilot Study to Investigate Efficient Complementary Transportation and Marketing Systems for South Dakota	

12. SOUTHERN MISSISSIPPI	DOT-OS-40089	•
Analysis of a Statewide Integrated Transportation System		
13. WEST VIRGINIA UNIVERSITY	DOT-OS-50127	•
Feasibility of Developing Low-Cost Measures of Demand for Public Transportation in Rural Areas		

#### XV. SAFETY

	<b>Contract No.</b>	
1. CORNELL UNIVERSITY	DOT-OS-40015	•
Safety Dynamics of Articulated Highway Vehicles		
2. FLORIDA TECHNOLOGICAL UNIVERSITY	DOT-OS-40020	•
Synthesis of a Model for Manpower Development in Transportation Safety		
3. UNIVERSITY OF ILLINOIS, URBANA	DOT-OS-50238	•
The Development of a Systems Risk Methodology for Single and Multi-Modal Transportation Systems		
4. KANSAS CITY UNIVERSITY	DOT-OS-60133	•
An Evaluation of the Effectiveness of Various Grade Crossing Illumination Strategies		
5. UNIVERSITY OF KENTUCKY	DT-RS-56-80C-00016	
Tire/Roadway Interaction and Its Effects on Vehicle Safety Trade-offs		
6. UNIVERSITY OF MICHIGAN, ANN ARBOR	DOT-OS-50113	•
Minimum Rolling Loss Truck Tires		
7. UNIVERSITY OF MICHIGAN, ANN ARBOR	DT-RS-56-80C-00020	
Advanced Transportation Accident Causal Models		
8. NEW YORK, POLYTECHNIC INSTITUTE OF	DOT-OS-50241	•
System Safety—An Interdisciplinary Approach to Transportation Safety		
9. NEW YORK, POLYTECHNIC INSTITUTE OF	DOT-OS-70057	•
Improving Pedestrian Crosswalk Safety on One-Way Street Networks		
10. UNIVERSITY OF OKLAHOMA	DOT-OS-30110	•
Analysis and Management of a Pipeline Safety Information System		
11. PENNSYLVANIA STATE UNIVERSITY	DOT-OS-60145	•
Investigation of the Transient Aspects of Hydroplaning		
12. UNIVERSITY OF PUERTO RICO, MAYAGUEZ	DT-RS-56-80C-00027	
Highway Conditions and Highway Accidents: A Multivariate Design Model		
13. UNIVERSITY OF SOUTH DAKOTA	DOT-OS-50121	•
A Field Comparison of Standard Emergency-Vehicle Signals with a Sequentially Fired Flash Tube Array		

<b>14. UNIVERSITY OF SOUTH DAKOTA</b>	DOT-OS-70071
The Psychophysics of Visual Acuity as a Function of Dynamic Figure/Background Relationships	
<b>15. UNIVERSITY OF SOUTHERN CALIFORNIA</b>	DOT-OS-50230
Seminars in Transportation Safety	
<b>16. STANFORD UNIVERSITY</b>	DOT-OS-30091
Fundamental Aspects of Crashworthiness	
<b>17. SYRACUSE UNIVERSITY</b>	DOT-OS-50124
Wear and Fracture Characteristics of Critical Components in Ground Transportation Systems	

#### **XVI. SEMINARS/CONSORTIA/STATEWIDE RESEARCH PROGRAMS**

	<b>Contract No.</b>
<b>1. CALIFORNIA INSTITUTE OF TECHNOLOGY</b>	DOT-OS-30119
Cal. Tech. Transportation Seminar Program	
<b>2. CLARK COLLEGE</b>	DOT-OS-30115
Continuing University Seminars and Forums on Transportation	
<b>3. UNIVERSITY OF MAINE</b>	DOT-OS-40085
Workshop Study of Infrastructure of Problems Hampering International Transportation and Trade Between Maine and Canada	
<b>4. MICHIGAN TECHNOLOGICAL UNIVERSITY</b>	DOT-OS-30096
Planning and Implementation of a University Consortium for Transportation Research in the Upper Great Lakes Region	
<b>5. UNIVERSITY OF NORTH FLORIDA</b>	DOT-OS-30114
Improve Transportation Planning Through Education, Application and Coordination	
<b>6. SOUTHERN ILLINOIS UNIVERSITY, EDWARDSVILLE</b>	DOT-OS-30117
University-Based Seminars for Industry and State and Local Government's	
<b>7. VIRGINIA POLYTECHNIC INSTITUTE</b>	DOT-OS-30097
A Comprehensive Transportation Research Program for the Commonwealth of Virginia	

#### **XVII. TRANSPORTATION INFORMATION SYSTEMS**

	<b>Contract No.</b>
<b>1. HOWARD UNIVERSITY</b>	DOT-OS-30121
Information Flow in Transportation Planning Agencies	
<b>2. NORTHWESTERN UNIVERSITY</b>	DOT-OS-40090
An Experimental Transportation Information Diffusion Unit	
<b>3. NORTHWESTERN UNIVERSITY</b>	DOT-OS-50128
Continued Development of An Experimental Regional Transportation Information Diffusion Unit	

<b>4. PURDUE UNIVERSITY</b>	DOT-OS-60148
Feasibility of and Design of Cost Effective Computer Based Information Systems to Increase Productivity of Present and Future Urban Transportation Systems	
<b>5. UNIVERSITY OF WISCONSIN, MILWAUKEE</b>	DOT-RC-92044
Development of Procedures for Improved Utilization of Research in Urban Transportation	

### **XVIII. TRANSPORTATION POLICY ANALYSES/IMPACTS**

	<b>Contract No.</b>
<b>1. ATLANTA UNIVERSITY</b>	DOT-OS-30103
Transportation Policy and Program Impact Analysis	
<b>2. GEORGE WASHINGTON UNIVERSITY</b>	DOT-OS-40083
Consumer Motivation and Participation in Transportation	
<b>3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>	DOT-OS-50239
Scenarios for Alternative Roles for the Federal Government in Transportation	
<b>4. MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b>	DOT-OS-50240
New Perspectives on Urban Transportation: Strategies for Overcoming Barriers to Innovation	
<b>5. UNIVERSITY OF NEBRASKA, LINCOLN</b>	DOT-RC-92020
Citizens' Perceptions of Highway Impacts	
<b>6. NEW YORK, POLYTECHNIC INSTITUTE OF</b>	DT-RS-56-80C-00022
An Assessment of the Interstate Highway Trade-in Process	
<b>7. NORTH CAROLINA A&amp;T STATE UNIVERSITY</b>	DOT-RC-92026
Empirical Test of the Utility of Attitudinal Measures for Short Term Public Transportation Planning	
<b>8. TEXAS SOUTHERN UNIVERSITY</b>	DOT-OS-60123
Strengthening Organizational Capabilities and Techniques for Comprehensive Transportation Planning	
<b>9. TEXAS SOUTHERN UNIVERSITY</b>	DOT-RC-82027
A Pilot Study to Evaluate Citizens Participation Models for Policy Planning	
<b>10. VILLANOVA UNIVERSITY</b>	DOT-OS-40098
Optimization of Citizen Participation in the Transportation Planning Process	

### **XIX. TRANSPORTATION SYSTEM/TRAFFIC CONTROL (URBAN, AIR, AND LARGE SCALE NETWORK)**

	<b>Contract No.</b>
<b>1. UNIVERSITY OF CALIFORNIA, BERKELEY</b>	DOT-OS-60128
The Feasibility of Off-Airport Passenger Terminals	
<b>2. HARVARD UNIVERSITY</b>	DOT-OS-30099
TASSIM: A Transportation and Air Shed Simulation Model	

3. UNIVERSITY OF ILLINOIS, URBANA Artificial Intelligence and Human Error Prevention—A Computer Aided Decision-Making Approach	DOT-OS-80020
4. UNIVERSITY OF ILLINOIS, URBANA Decision Models for Transportation Network Capacity Expansion	DOT-OS-80021
5. UNIVERSITY OF LOWELL Demand-Responsive Decentralized Urban Traffic Control	DOT-RC-92015
6. UNIVERSITY OF MARYLAND Improved Software for Computerized Urban Traffic Control Systems	DOT-OS-60134
7. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Dynamic Detection and Identification of Incidents on Freeways	DOT-OS-60137
8. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Operator Workload Measurement	DOT-OS-70055
9. UNIVERSITY OF MINNESOTA Workshop in Computer Traffic Control	DOT-OS-40088
10. UNIVERSITY OF MINNESOTA Distributed Computer Systems for Traffic Control	DOT-OS-50114
11. UNIVERSITY OF MINNESOTA Development and Evaluation of Optimal Control Strategies for Large Scale Urban Transportation Networks	DOT-RC-82008
12. UNIVERSITY OF MINNESOTA Reliable Decentralized Control Strategies for Freeway Regulation	DOT-RC-92018
13. NEW YORK, POLYTECHNIC INSTITUTE OF Decentralized Control of Street Traffic	DOT-RC-92023
14. NORTHWESTERN UNIVERSITY President's Proposed Aviation Act of 1975	DOT-OS-60163
15. OHIO STATE UNIVERSITY Fundamental Studies in Automatic Longitudinal Control of Vehicles	DOT-OS-40100
16. UNIVERSITY OF PENNSYLVANIA Optimal Control of Air Traffic	DOT-OS-70065
17. UNIVERSITY OF PITTSBURGH Software Reliability in Air Traffic Control Systems	DOT-RC-92031
18. UNIVERSITY OF PITTSBURGH System Structure for Software Reliability in Enroute ATC System	DT-RS-56-80C-00026
19. RENSSELAER POLYTECHNIC INSTITUTE The Development of UTCS/NETSIM/ICG: An Integrated Urban Traffic Control System: Network Simulation Interactive Computer Graphics Program	DT-RS-56-80C-00028
20. UNIVERSITY OF SOUTHERN CALIFORNIA Characteristics of Multilane Traffic Flow from Aerial Data	DOT-OS-50122

21. UNIVERSITY OF TEXAS, AUSTIN A System Analysis Procedure for Estimating the Capacity of An Airport	DOT-OS-50232
22. UNIVERSITY OF TEXAS, AUSTIN Improving Flow Management and Control Via Shortest Path Analysis	DOT-OS-70074
23. UNIVERSITY OF TEXAS, AUSTIN Improvement of Large Scale Network Procedures	DOT-RC-92039
24. UTAH STATE UNIVERSITY A. Kinetic Model for Traffic Flow	DOT-OS-40097
25. UTAH STATE UNIVERSITY A New Continuum for Traffic Flow	DOT-RC-82018
26. UNIVERSITY OF WASHINGTON Seminar on the Utility of Interactive Graphics in Transportation Systems Design	DOT-OS-40012
27. UNIVERSITY OF WASHINGTON Increasing Network Flow Simulation Model Performance Through Graphic and Heuristic User Aids.	DOT-RC-82021
28. UNIVERSITY OF WASHINGTON Development of Improved Urban Travel Pattern Mapping Tools for Analysis of Land-Use/Transportation Interrelationships	DOT-RC-92041
29. UNIVERSITY OF WEST VIRGINIA Antenna System Polarization and Location for Microwave Landing System	DOT-OS-60176

## XX. TRAVEL BEHAVIOR OF SPECIAL GROUPS

	<b>Contract No.</b>
1. BISHOP COLLEGE The Relationship of Established Transportation Routes to the Delivery of Health Care Services for the Elderly and Poor	DOT-RC-82001
2. UNIVERSITY OF CALIFORNIA, LOS ANGELES Determining the Future Mobility Needs for the Elderly: Development of a Methodology	DOT-OS-50109
3. GALLAUDET COLLEGE A Study to Identify the Problems that Deaf People May Encounter with Metro and Dial-a-Bus in Metropolitan Washington	DOT-OS-50110
4. UNIVERSITY OF MASSACHUSETTS, AMHERST Regional Transportation Systems to Meet the Special Educational Needs of Handicapped Individuals	DOT-OS-50227
5. NEW YORK, POLYTECHNIC INSTITUTE OF The Mobility of People and Goods in the Urban Environment	DOT-OS-30095
6. NEW YORK, POLYTECHNIC INSTITUTE OF Mobility of the Handicapped and Elderly	DOT-OS-70084
7. NEW YORK, STATE UNIVERSITY OF, BUFFALO A Study of Problems of the Carless	DOT-OS-30098

- 8. NORTH CAROLINA A&T STATE UNIVERSITY** DOT-OS-60140  
Travel Needs and Solutions of Low and Middle Income Urban  
Residents: A Comparative Study

## **XXI. TRAVEL FORECASTING MODELS**

	Contract No.
1. BROWN UNIVERSITY Modal Choice and the Demand for Urban Transportation	DOT-OS-40078
2. BROWN UNIVERSITY Multimodal Traffic Equilibrium Network Models and Algorithms	DT-RS-56-80C-00007
3. UNIVERSITY OF CALIFORNIA, LOS ANGELES The Effect of Employer Subsidized Parking on Commuting Behavior and Transportation System Performance	DOT-OS-80011
4. CARNEGIE-MELLON UNIVERSITY Urban Passenger Travel Demand	DOT-OS-40006
5. UNIVERSITY OF IOWA The Development and Test of Mathematical Models of Traveler Perceptions and Decisions	DOT-RC-82029
6. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Experiments to Clarify Priorities in Urban Travel Forecasting Research and Development	DOT-OS-30120
7. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Understanding, Prediction and Evaluation of Transportation Related Consumer Behavior	DOT-OS-70054
8. MASSACHUSETTS INSTITUTE OF TECHNOLOGY Efficient Data Collection Schemes for Disaggregate Travel Demand Models Estimation	DT-RS-56-80C-00017
9. NORTHWESTERN UNIVERSITY Second International Conference on Issues in Behavioral Travel Demand Theory and Estimation	DOT-OS-50117
10. NORTHWESTERN UNIVERSITY Consumer Oriented Transportation Service Planning	DOT-OS-60141
11. NORTHWESTERN UNIVERSITY Consumer Oriented Transportation Service: Modification and Evaluation	DOT-OS-70062
12. NORTHWESTERN UNIVERSITY Identification of Conditions for Effective Transferability of Disaggregate Choice Models	DT-RS-56-80C-00024
13. PENNSYLVANIA STATE UNIVERSITY Review and Compilation of Demand Forecasting Experiences: A Manual for Transportation Planners	DOT-OS-60146
14. WEST VIRGINIA UNIVERSITY Synthetic Travel Forecasting using Traffic Count Correlations	DOT-RC-92043

- 15. UNIVERSITY OF WISCONSIN, MILWAUKEE**  
**Predicting Public's Response to Prospective Transportation Policies Based  
on Their Stated Intention**

DOT-RC-82023

## **XXII. TUNNELING TECHNOLOGY**

	<b>Contract No.</b>	
<b>1. UNIVERSITY OF CALIFORNIA, BERKELEY</b> Stand-up Time of Tunnels in Squeezing Ground	DOT-OS-50108	•
<b>2. CALIFORNIA STATE UNIVERSITY, SACRAMENTO</b> Analytical Techniques for Safety and Performance of Subsurface Transportation Structures	DOT-OS-40016	•
<b>3. MASSACHUSETTS INSTITUTE OF TECHNOLOGY</b> Improved Design Procedure for Tunnel Supports	DOT-OS-60136	•
<b>4. UNIVERSITY OF MINNESOTA</b> Hydraulic Transportation and Solids Separation of Excavated Material in Tunnels	DOT-OS-40087	•
<b>5. STANFORD UNIVERSITY</b> Development of a Rational Design Methodology for Soft Ground Grouted Tunnels	DOT-OS-50123	•
<b>6. STANFORD UNIVERSITY</b> Development of Research in the Construction of Transportation Facilities: A Study of Needs, Objectives, Resources, and Mechanisms for Implementation	DOT-OS-60150	•

## **XXIII. URBAN TRANSPORTATION FACILITIES/ SYSTEMS**

	<b>Contract No.</b>	
<b>1. UNIVERSITY OF CALIFORNIA, BERKELEY</b> Optimized Organization of the Urban Passenger Transportation Enterprise as Determined by Technology and Socio-Economic Environment	DOT-OS-40079	•
<b>2. UNIVERSITY OF CALIFORNIA, LOS ANGELES</b> Dynamic Interactions and Optimal Design of PRT Vehicles and Evaluated Guideways	DOT-OS-40080	•
<b>3. CLARK COLLEGE</b> Neighborhood Viability and Transit Development: An Ecological Model for Land-Use Forecasting in Atlanta	DOT-OS-70044	•
<b>4. CLARK COLLEGE</b> Assessing the Potential for Individual Energy Savings through Coordinated Transit Planning and Neighborhood District Development	DT-RS-56-80C-00011	
<b>5. UNIVERSITY OF COLORADO</b> Public Transportation Implementation Strategies: The Case of Boulder, Colorado	DOT-OS-30100	•

6. CORNELL UNIVERSITY	DOT-OS-40003	*
Mass Transit Development for Small Urban Areas: A Case Study— Tompkins County, N.Y.		
7. CORNELL UNIVERSITY	DT-RS-56-80C-00012	
Short-Range Operations Planning Models for Transit Systems		
8. DARTMOUTH COLLEGE	DT-RS-56-80C-00014	
A Unified Approach to Performance Standards and Fare Policies for Urban Transit Systems		
9. JOHNS HOPKINS UNIVERSITY	DOT-OS-40084	*
Workshop Seminar on Baltimore Transit Planning and Impact		
10. MASSACHUSETTS INSTITUTE OF TECHNOLOGY	DOT-OS-70053	
Utilization of Vehicle, Labor and Fixed Facility Resources in Multi- Modal Transportation Systems		
11. NORTHWESTERN UNIVERSITY	DOT-OS-80018	*
Control of Service Reliability in Bus Transit Networks		
12. UNIVERSITY OF PENNSYLVANIA	DOT-OS-30101	*
Study of Efficiency and Productivity of Urban Transportation Systems		
13. UNIVERSITY OF PENNSYLVANIA	DOT-OS-40092	*
Development and Application of a Plan Programming Model for Accessibility Urban Corridors		
14. UNIVERSITY OF PENNSYLVANIA	DOT-OS-50228	*
Primary Services Versus Support Functions in Urban Transit		
15. UNIVERSITY OF PENNSYLVANIA	DOT-RC-92030	
Development, Testing and Applications of Transportation Supply Models		
16. RICE UNIVERSITY	DOT-OS-40007	*
Value Capture Policy Research—The Economic, Legal, and Community Design Implications of Capturing Land Value Escalation Resulting from Public Investment in Transit Facilities		
17. STANFORD UNIVERSITY	DOT-OS-70003	*
Advanced Urban Transportation System Analysis Methodology		
18. SYRACUSE UNIVERSITY	DOT-OS-30118	*
Transportation Systems for Decentralized Metropolitan Regions		
19. UNIVERSITY OF VIRGINIA	DOT-OS-50233	
Methodology for the Design of Urban Transportation Facilities		
20. YALE UNIVERSITY	DOT-OS-40099	*
Long Term Subsidies to Bus Transit in Connecticut's Medium-Size Cities		

## **PART III**

### **Listing of All Contracts in FY 1973 – FY 1980**

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1973**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1973</b>	<b>1974</b>	<b>1975</b>
DOT-OS-30103	ATLANTA UNIVERSITY S. Davis "Transportation Policy and Program Impact Analysis"	\$ 67,000	\$ 67,000	\$
DOT-OS-30119	CALIFORNIA INSTITUTE OF TECHNOLOGY J. Pierce "Cal Tech. Transportation Seminar Program"	25,000		
DOT-OS-30107	CLARION STATE COLLEGE F. Battista "The Economic, Social, and Physical Impact of Rural Transportation in Venango County"	18,547		
DOT-OS-30115	CLARK COLLEGE R. Kronley "Continuing University Seminars and Forums on Transportation"	40,000		
DOT-OS-30100	UNIVERSITY OF COLORADO W. Yordon "Public Transportation Implementation Strategies: The Case of Boulder, Colorado"	59,140	64,000	
DOT-OS-30113	CORNELL UNIVERSITY P. deBoer "Combustion in Hydrogen-Fueled Transportation Systems"	35,055	53,000	
DOT-OS-30122	GEORGE WASHINGTON UNIVERSITY V. Coates "Revitalization of Small Communities through Transportation Options"	82,626	88,000	
DOT-OS-30099	HARVARD UNIVERSITY G. Ingram "TASSIM: A Transportation and Air Shed Simulation Model"	59,994	72,500	65,000
DOT-OS-30121	HOWARD UNIVERSITY L. Beasley "Information Flow in Transportation Planning Agencies"	46,975	4,650	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1973, continued**

<u>Contract No.</u>	<u>University/Principal Investigator/Title</u>	<u>Funding</u>			
		<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
DOT-OS-30092	UNIVERSITY OF ILLINOIS, CHICAGO CIRCLE M. Silver “An Integrated Engineering—Preservation, Improvement and Replacement of Elevated Transportation Structures”	\$ 98,920	\$ 98,932	\$	\$
DOT-OS-30106	IOWA STATE UNIVERSITY R. Carstens “Integrated Analysis of Small Cities Intercity Transportation to Facilitate the Achievement of Regional Urban Goals”	124,947	149,993	8,441	
DOT-OS-30109	LOWELL TECHNOLOGICAL INSTITUTE A. Mironer “Spills of Hazardous Chemicals on Waterways”	12,509			
DOT-OS-30104	MASSACHUSETTS INSTITUTE OF TECHNOLOGY K. Polenske “A Multi-Regional Input-Output (MRIO) Study of U.S. Commodity Freight Shipments”	124,999	135,000	125,000	
DOT-OS-30120	MASSACHUSETTS INSTITUTE OF TECHNOLOGY M. Manheim “Experiments to Clarify Priorities in Urban Travel Forecasting Research and Development”	64,980	130,860	75,000	7,000
DOT-OS-30096	MICHIGAN TECHNOLOGICAL UNIVERSITY J. Kent “Planning and Implementation of a University Consortium for Transportation Research in the Upper Great Lakes Region”	51,470			
DOT-OS-30095	NEW YORK, POLYTECHNIC INSTITUTE OF J. Falcocchio/K. Crowley “The Mobility of People and Goods in the Urban Environment”	200,000	100,000	25,000	
DOT-OS-30098	NEW YORK, STATE UNIVERSITY OF,— BUFFALO R. Paaswell/W. Recker “A Study of Problems of the Carless”	52,918	54,847	58,835	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1973, continued**

<u>Contract No.</u>	<u>University/Principal Investigator/Title</u>	<u>Funding</u>			
		<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
DOT-OS-30102	NORTH CAROLINA STATE UNIVERSITY  B. Huang “An Ecological System Approach to Community Noise Abatement”	\$ 48,500	\$	\$	\$
DOT-OS-30114	UNIVERSITY OF NORTH FLORIDA  W. Rose “Improve Transportation Planning Through Education, Application and Coordination”	44,320			
DOT-OS-30110	UNIVERSITY OF OKLAHOMA  M. Devine “Analysis and Management of a Pipeline Safety Information System”	78,887			
DOT-OS-30101	UNIVERSITY OF PENNSYLVANIA  S. Gupta “Study of Efficiency and Productivity of Urban Transportation Systems”	92,475			
DOT-OS-30105	PENNSYLVANIA STATE UNIVERSITY, MIDDLETON  T. Brown “Economic Analysis of the Taxicab Industry in Pennsylvania: Demand and Cost”	19,038			
DOT-OS-30094	SOUTHERN UNIVERSITY  R. Steptoe “A Measurement of Highway Induced Changes in Land Use, Population Density, and Minority Recreational Opportunities”	135,000	53,820	59,468	
DOT-OS-30117	SOUTHERN ILLINOIS UNIVERSITY, EDWARDSVILLE  G. Arnold “University-Based Seminars for Industry and State and Local Government(s)”	17,150			
DOT-OS-30091	STANFORD UNIVERSITY  G. Herrmann “Fundamental Aspects of Crashworthiness”	61,000		59,400	
DOT-OS-30111	STANFORD UNIVERSITY  J. Powell “Closed-Loop Control of Internal Combustion Exhaust Emissions”	31,228	30,000	30,000	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1973, continued**

Contract No.	University/Principal Investigator/Title	Funding			
		1973	1974	1975	1976
DOT-OS-30118	SYRACUSE UNIVERSITY G. Birkhead “Transportation Systems for Decentralized Metropolitan Regions”	\$ 9,290	\$	\$	\$
DOT-OS-30089	UNIVERSITY OF TEXAS, AUSTIN E. Hixson “Vehicle Noise Studies”	41,830			
DOT-OS-30093	UNIVERSITY OF TEXAS, AUSTIN C. Walton “Transportatin to Fulfill Human Needs in the Rural/Urban Environment”	280,000	375,000	273,000	23,970
DOT-OS-30116	UTAH STATE UNIVERSITY N. Taylor “Freight Rate Structure Study”	35,000	35,000	4,500	
DOT-OS-30097	VIRGINIA POLYTECHNIC INSTITUTE J. Dickey “A Comprehensive Transportation Research Program for the Commonwealth of Virginia”	50,000	75,000		
DOT-OS-30108	WASHINGTON UNIVERSITY, ST. LOUIS B. Szabo “Advanced Design Technology for Rail Transportation Vehicles”	84,400	87,600	48,600	
DOT-OS-30112	UNIVERSITY OF WISCONSIN, MADISON N. Beachley/A. Frank “Increased Fuel Economy in Transportation Systems by Use of Energy Management”	55,730	66,000	92,270	
DOT-OS-30090	UNIVERSITY OF WISCONSIN, MILWAUKEE E. Schenker “Seminar on Port Planning and Development as Related to Problems of U.S. Ports and U.S. Coastal Environment”	38,033			
		\$2,286,961	\$1,741,202	\$859,514	\$ 95,970

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1974**

Contract No.	University/Principal Investigator/Title	Funding				
		1974	1975	1976	1977	1978
DOT-OS-40008	UNIVERSITY OF ALASKA, FAIRBANKS L. Gorsuch “Transportation System Development for Alaska”	\$ 74,500	\$147,959	\$	\$	\$ 55,000 \$ 1,400
DOT-OS-40078	BROWN UNIVERSITY B. Chinitz “Modal Choice and the Demand for Urban Transportation”	24,000				
DOT-OS-40079	UNIVERSITY OF CALIFORNIA, BERKELEY E. Crossman “Optimized Organization of the Urban Passenger Transportation Enterprise as Determined by Technology and Socio- Economic Environment”	44,747	51,046			5,000
DOT-OS-40111	UNIVERSITY OF CALIFORNIA, LOS ANGELES W. Van Vorst “Research Studies Pertaining to Hydrogen Car Development”		61,681			
DOT-OS-40080	UNIVERSITY OF CALIFORNIA, LOS ANGELES R. Nelson “Dynamic Interactions and Optimal Design of PRT Vehicles and Elevated Guideways”	30,726	61,689	28,000		
DOT-OS-40016	CALIFORNIA STATE UNIVERSITY, SACRAMENTO L. Gabriel “Analytical Techniques for Safety and Performance of Subsurface Transporta- tion Structures”	26,727	49,971	39,965		
DOT-OS-40006	CARNEGIE-MELLON UNIVERSITY M. Wohl “Urban Passenger Travel Demand”	50,000				
DOT-OS-40081	CARNEGIE-MELLON UNIVERSITY T. Au “Ride Sharing Paratransit Ex- periments”	70,000	99,993	90,000	5,796	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1974, continued**

<u>Contract No.</u>	<u>University/Principal Investigator/Title</u>	<u>Funding</u>					
		<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1980</u>
DOT-OS-40082	CHICAGO STATE UNIVERSITY I. Roth "Declining Mass Transportation, Fear, and the Journey to Work"	\$21,353	\$	\$	\$	\$	\$
DOT-OS-40003	CORNELL UNIVERSITY A. Meyburg "Mass Transit Development for Small Urban Areas: A Case Study—Tomp- kins County, N.Y."	48,690	54,997	46,632			
DOT-OS-40015	CORNELL UNIVERSITY A. Krawter "Safety Dynamics of Articulated Highway Vehicles"	29,806					
DOT-OS-40020	FLORIDA TECHNOLOGICAL UNIVERSITY G. Shrader "Synthesis of a Model for Manpower Development in Transportation Safety"		20,000	30,000			
DOT-OS-40083	GEORGE WASHINGTON UNIVERSITY J. Margolin "Consumer Motivation and Participa- tion in Transportation"		52,746	53,000	35,000		
DOT-OS-40019	UNIVERSITY OF IOWA K. Dueker "Re-Use Planning of Transportation Property Abandonments"	58,000					
DOT-OS-40084	JOHNS HOPKINS UNIVERSITY J. Fisher "Workshop Seminar on Baltimore Transit Planning and Impact"	42,969					
DOT-OS-40085	UNIVERSITY OF MAINE H. Waters "Workshop Study of Infrastructure of Problems Hampering International Transportation and Trade Between Maine and Canada"	41,560					

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1974, continued**

Contract No.	University/Principal Investigator/Title	Funding				
		1974	1975	1976	1977	1978
DOT-OS-40002	MASSACHUSETTS INSTITUTE OF TECHNOLOGY J. Sussman "Methodologies for Developing and Evaluating Effective Railroad Networks"	\$90,000	\$ 90,000	\$80,000	\$	\$
DOT-OS-40004	MASSACHUSETTS INSTITUTE OF TECHNOLOGY H. Marcus "Utilizing the Existing Regulatory Structure to Influence Port Development"	50,000				
DOT-OS-40086	MASSACHUSETTS INSTITUTE OF TECHNOLOGY J. Smith "Development of the Valved Hot-Gas Engine"	49,948				
DOT-OS-40087	UNIVERSITY OF MINNESOTA C. Nelson "Hydraulic Transportation and Solids Separation of Excavated Material in Tunnels"	60,000				
DOT-OS-40088	UNIVERSITY OF MINNESOTA D. Gerlough "Workshop in Computer Traffic Control"	15,150				
DOT-OS-40005	NORTH CAROLINA A&T STATE UNIVERISTY A. Saltzman "Rural Transportation Feasibility Study"	\$2,000	103,080			
DOT-OS-40001	NORTHWESTERN UNIVERSITY P. Stopher "A Method for Assessing Pricing and Structural Changes on Transport Mode Use"	50,393	113,227	32,043	1,500	
DOT-OS-40090	NORTHWESTERN UNIVERSITY G. Rath "An Experimental Transportation Information Diffusion Unit"	69,706				

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1974, continued**

Contract No.	University/Principal Investigator/Title	Funding					
		1974	1975	1976	1977	1978	1980
DOT-OS-40100	OHIO STATE UNIVERSITY R. Fenton "Fundamental Studies in Automatic Longitudinal Control of Vehicles"	\$99,923	\$	\$	\$	\$	\$
DOT-OS-40091	UNIVERSITY OF OKLAHOMA P. Egle "Non-Destructive Measurement of Longitudinal Rail Stresses"	50,000					
DOT-OS-40092	UNIVERSITY OF PENNSYLVANIA E. Morlok "Development and Application of a Plan Programming Model for Accessibility Urban Corridors"	69,928	75,240	30,000			
DOT-OS-40093	UNIVERSITY OF PENNSYLVANIA B. Paul "Improved Wheel and Rail Performance Control of Contact Stress"	29,442	38,303				
DOT-OS-40009	PENNSYLVANIA STATE UNIVERSITY D. Roy "Advanced Technology Materials Applied to Guideways, Highways, and Airport Runways"	30,000	30,000	5,969			
DOT-OS-40010	PENNSYLVANIA STATE UNIVERSITY W. Park "Objective Measures of Ride Quality"	35,990					
DOT-OS-40094	PENNSYLVANIA STATE UNIVERSITY J. Nelson "The Effects of Mobile Source and Aircraft Noise and Air Pollutants on Residential Property Values"	58,000					
DOT-OS-40095	PRINCETON UNIVERSITY P. Lion "Re-establishing Rail Service in Conjunction with New Feeder Systems"	88,535	101,660				

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1974, continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>				
		<b>1974</b>	<b>1975</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>
DOT-OS-40007	RICE UNIVERSITY C. Sharpe "Value Capture Policy Research—The Economic, Legal, and Community Design Implications of Capturing Land Value Escalation Resulting from Public Investment in Transit Facilities"	75,000	75,000	25,000		
DOT-OS-40089	SOUTHERN MISSISSIPPI J. Peterson "Analysis of a Statewide Integrated Transportation System"	60,000	80,000	54,942		
DOT-OS-40096	UNIVERSITY OF TENNESSEE F. Davis, Jr. "Development of a Strategy for Successful Commuter Pools in Urban Areas"	25,000	75,000	76,318		
DOT-OS-40097	UTAH STATE UNIVERSITY W. Phillips "A Kinetic Model for Traffic Flow"	34,000		36,000		
DOT-OS-40098	VILLANOVA UNIVERSITY J. Schuster "Optimization of Citizen Participation in the Transportation Planning Process"	20,000	20,000	20,000		
DOT-OS-40012	UNIVERSITY OF WASHINGTON J. Schneider "Seminar on the Utility of Interactive Graphics in Transportation Systems Design"	21,479				
DOT-OS-40099	YALE UNIVERSITY R. Schmenner "Long Term Subsidies to Bus Transit in Connecticut's Medium-Size Cities"	43,819				
		\$1,875,818	\$1,350,165	\$599,869	\$12,296	\$55,000
						\$1,400

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1975**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1975</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>
DOT-OS-50107	ARIZONA STATE UNIVERSITY N. Cooperrider "Guideway Vehicle Cost Reduction"	\$ 66,000	\$ 62,000	\$	\$
DOT-OS-50108	UNIVERSITY OF CALIFORNIA, BERKELEY T. Brekke "Stand-up Time of Tunnels in Squeezing Ground"	75,941	71,000	56,000	
DOT-OS-50237	UNIVERSITY OF CALIFORNIA, BERKELEY W. Garrison "Alternative Roles for Personal Transporta- tion"	150,000	120,000	11,966	
DOT-OS-50109	UNIVERSITY OF CALIFORNIA, LOS ANGELES M. Wachs "Determining the Future Mobility Needs for the Elderly: Development of a Methodology"	38,000	50,000		
DOT-OS-50225	UNIVERSITY OF COLORADO D. Gary "Seminar on Personal Rapid Transit"	27,000			
DOT-OS-50043	COLORADO STATE UNIVERSITY E. Vlachos "Secondary Impacts and Consequences of Highway Projects"	96,559			
DOT-OS-50110	GALLAUDET COLLEGE I. Winakur "A Study to Identify the Problems that Deaf People May Encounter with Metro and Dial- a-Bus in Metropolitan Washington"	49,140			
DOT-OS-50226	GEORGIA INSTITUTE OF TECHNOLOGY J. Lai "Low Cost Bicycle Path Pavements"	40,000	31,601		
DOT-OS-50238	UNIVERSITY OF ILLINOIS, URBANA A. Ang/R. White "The Development of a Systems Risk Methodology for Single and Multi-Modal Transportation System"	129,560	30,000		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1975, continued**

<u>Contract No.</u>	<u>University/Principal Investigator/Title</u>	<u>Funding</u>			
		<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>
DOT-OS-50111	UNIVERSITY OF KENTUCKY J. Deacon "An Elusive Dimension of the Urban Transportation Problem: The Land Use-Transportation Interface"	\$ 29,000	\$	\$	\$
DOT-OS-50227	UNIVERSITY OF MASSACHUSETTS W. Goss "Regional Transportation Systems to Meet the Special Educational Needs of Handicapped Individuals"	85,000			
DOT-OS-50112	MASSACHUSETTS INSTITUTE OF TECHNOLOGY P. Roberts "Analysis of Freight Markets"	92,332	76,500		
DOT-OS-50239	MASSACHUSETTS INSTITUTE OF TECHNOLOGY A. Friedlaender "Scenarios for Alternative Roles of the Federal Government in Transportation"	240,000	160,000		75,000
DOT-OS-50240	MASSACHUSETTS INSTITUTE OF TECHNOLOGY A. Altshuler "New Perspectives on Urban Transportation: Strategies for Overcoming Barriers to Innovation"	240,000	175,000		
DOT-OS-50113	UNIVERSITY OF MICHIGAN S. Clark "Minimum Rolling Loss Truck Tires"	67,650	53,900		
DOT-OS-50044	MICHIGAN STATE UNIVERSITY W. Taylor "Transportation Investment Requirements and Growth Patterns in Michigan"	31,297	42,383		
DOT-OS-50114	UNIVERSITY OF MINNESOTA L. Kinney "Distributed Computer Systems for Traffic Control"	47,742	62,000	55,000	
DOT-OS-50241	NEW YORK, POLYTECHNIC INSTITUTE OF L. Pignataro "System Safety—An Interdisciplinary Approach to Transportation Safety"	135,000		160,000	135,000

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1975, continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1975</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>
DOT-OS-50115	NORTH CAROLINA A&T STATE UNIVERSITY J. Johnson “Evaluating Rural Public Transportation Demonstrations”	\$ 73,349	\$	\$ 69,600	\$ 70,000
DOT-OS-50116	UNIVERSITY OF NORTH FLORIDA J. Smith “Study of Unions, Management Rights, and the Public Interest in Mass Transit”	59,857	50,000		
DOT-OS-50117	NORTHWESTERN UNIVERSITY P. Stopher “Second International Conference on Issues in Behavioral Travel Demand Theory and Estimation”	16,116			
DOT-OS-50118	NORTHWESTERN UNIVERSITY J. Schofer “Transportation Energy Consumption and Urban Form Relationship”	42,000	29,852		
DOT-OS-50128	NORTHWESTERN UNIVERSITY G. Rath “Continued Development of An Experimental Regional Transportation Information Diffusion Unit”	56,737			
DOT-OS-50119	UNIVERSITY OF PENNSYLVANIA I. Zandi “Transport of Solid Commodities via Freight Pipeline”	64,529	66,000	40,000	
DOT-OS-50228	UNIVERSITY OF PENNSYLVANIA A. Tomazinis “Primary Services Versus Support Functions in Urban Transit”	84,461			
DOT-OS-50120	PENNSYLVANIA STATE UNIVERSITY A. Stenger “An Experiment in Freight Modal Choice Delineating the Rail-Truck Interface”	42,266			
DOT-OS-50242	UNIVERSITY OF PITTSBURGH J. Drake “Alternative Roles of the Automobile”	126,066			

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1975, continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1975</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>
DOT-OS-50121	UNIVERSITY OF SOUTH DAKOTA J. Berkhout "A Field Comparison of Standard Emergency Vehicle Signals with a Sequentially Fired Flash Tube Array"	27,057			
DOT-OS-50229	SOUTH DAKOTA STATE UNIVERSITY R. Rudel "A Pilot Study to Investigate Efficient Complementary Transportation and Marketing Systems for South Dakota"	89,723			
DOT-OS-50122	UNIVERSITY OF SOUTHERN CALIFORNIA A. Gafarian "Characteristics of Multilane Traffic Flow from Aerial Data"	60, 291			
DOT-OS-50230	UNIVERSITY OF SOUTHERN CALIFORNIA R. Canaday "Seminars in Transportation Safety"	26,718	1,682		
DOT-OS-50123	STANFORD UNIVERSITY G. Clough "Development of a Rational Design Methodology for Soft Ground Grouted Tunnels"	61,501	52,618		59,805
DOT-OS-50231	STEVENS INSTITUTE OF TECHNOLOGY A. Lesser, Jr. "A Publico System for Highly Congested Urban Areas"	94,430			
DOT-OS-50124	SYRACUSE UNIVERSITY P. Keller, Jr. "Wear and Fracture Characteristics of Critical Components in Ground Transportation Systems"	73,142	61,903		
DOT-OS-50125	UNIVERSITY OF TENNESSEE E. Patton "Developing Local Strategies as Alternatives to Abandonment of Light Density Rail Lines"	84,420			

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1975, continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>				
		<b>1975</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>	<b>1979</b>
DOT-OS-50126	UNIVERSITY OF TEXAS, AUSTIN A. Healey "Ride Quality Studies on Ground-Based Transportation Systems"	\$ 40,000	\$ 32,000	\$	\$	\$
DOT-OS-50132	UNIVERSITY OF TEXAS, AUSTIN B. McCulloch/W. Dunlay "A System Analysis Procedure for Estimating the Capacity of an Airport"	48,000	45,000			
DOT-OS-50045	TUFTS UNIVERSITY H. Field "Impacts of Tourist Transportation and People Overloads on National Historic and Scenic Monuments and Strategies for their Resolution"	68,087				
DOT-OS-50233	UNIVERSITY OF VIRGINIA L. Hoel/M. Demetsky "Methodology for the Designs of Urban Transportation Facilities"	64,575		60,000	70,000	6,000
DOT-OS-50127	WEST VIRGINIA UNIVERSITY B. Byrne "Feasibility of Developing Low-Cost Measures of Demand for Public Transportation in Rural Areas"	60,000	50,000			
		<b>\$3,003,546</b>	<b>\$1,323,439</b>	<b>\$452,566</b>	<b>\$339,805</b>	<b>\$70,000</b>
						<b>\$6,000</b>

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1976**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1976</b>	<b>1977</b>	<b>1978</b>	<b>1979</b>
DOT-OS-60126	UNIVERSITY OF ALABAMA C. Johnson "Applications of Disturbance Accomodating Control Theory to Vehicle Active Ride Control Problems"	\$ 26,121	\$	\$	\$
DOT-OS-60127	ARIZONA STATE UNIVERSITY N. Berman "Spatial and Temporal Resolutions of Urban Air Pollution Models for Evaluation of Transportation Strategies in Phoenix, Arizona"	47,694		48,500	
DOT-OS-60128	UNIVERSITY OF CALIFORNIA, BERKELEY A. Kanafani "The Feasibility of Off Airport Passenger Terminals"	44,748			
DOT-OS-60129	CARNEGIE-MELLON UNIVERSITY R. Uher "Energy Management for Electric Powered Transportation Systems"	95,840	75,000		44,037
DOT-OS-60130	DUKE UNIVERSITY J. Wilson "Dynamic Experiments of Alternative Guideway-Vehicle Systems"	51,000	60,000	5,351	
DOT-OS-60131	UNIVERSITY OF ILLINOIS, CHICAGO CIRCLE A. Sen "Formulation of Conventional and Paratransit Policy Recommendations for Low Density Areas: A Study of Metropolitan Chicago"	69,970			
DOT-OS-60132	UNIVERSITY OF ILLINOIS, URBANA H. Korst "Full Scale Vehicle Drag Component Evaluation by Coast-Down Testing on Level and Inclined Roads and Tracks"	34,455			
DOT-OS-60133	KANSAS CITY UNIVERSITY E. Russell "An Evaluation of the Effectiveness of Various Grade Crossing Illumination Strategies"	49,952			
DOT-OS-60134	UNIVERSITY OF MARYLAND W. Levine/J. Baras "Improved Software for Computerized Urban Traffic Control Systems"	43,594		48,000	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1976, Continued**

Contract No.	University/Principal Investigator/Title	Funding		
		1976	1977	1978
DOT-OS-60135	MASSACHUSETTS INSTITUTE OF TECHNOLOGY D. Wormley "Assessment of Technology Base and Applied Research for Non-Contacting Vehicle Suspension and Propulsion Systems"	\$83,597	\$2,500	\$73,000
DOT-OS-60136	MASSACHUSETTS INSTITUTE OF TECHNOLOGY H. Einstein "Improved Design Procedure for Tunnel Supports"	70,000		
DOT-OS-60137	MASSACHUSETTS INSTITUTE OF TECHNOLOGY A. Wilsky "Dynamic Detection and Identification of Incidents on Freeways"	61,126	6,100	
DOT-OS-60138	MASSACHUSETTS INSTITUTE OF TECHNOLOGY H. Marcus "Offshore Liquified Natural Gas Terminals"	70,000		
DOT-OS-60139	NEW YORK, POLYTECHNIC INSTITUTE OF E. Pearce "Seminar on Polymeric Materials and their Use in Transportation"	29,545		
DOT-OS-60140	NORTH CAROLINA A&T STATE UNIVERSITY L. Sen "Travel Needs and Solutions of Low and Middle Income Urban Residents: A Comparative Study"	54,088		80,000
DOT-OS-60141	NORTHWESTERN UNIVERSITY L. Moses "President's Proposed Aviation Act of 1975"	35,837		
DOT-OS-60142	OREGON STATE UNIVERSITY R. Hicks "The Energy, Economic and Environmental Consequences of Oversized, Overweight Vehicles"	99,998		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1976, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1976</b>	<b>1977</b>	<b>1978</b>	<b>1979</b>
DOT-OS-60143	UNIVERSITY OF PENNSYLVANIA I. Zandi "International Symposium on Freight Pipeline"	\$ 26,071	\$	\$	\$
DOT-OS-60144	UNIVERSITY OF PENNSYLVANIA B. Paul "Fundamental Studies of Phenomena Related to Wheel-Rail Contact Stresses"	35,715			
DOT-OS-60145	PENNSYLVANIA STATE UNIVERSITY J. Henry "Investigation of the Transient Aspects of Hydroplaning"	70,227		59,991	
DOT-OS-60146	PENNSYLVANIA STATE UNIVERSITY Y. Chan "Review and Compilation of Demand Forecasting Experiences: A Manual for Transportation Planners"	49,243			
DOT-OS-60147	PRINCETON UNIVERSITY L. Sweet "Experimental Research on Rail Vehicle Safety Using Dynamically Scaled Models"	69,308	60,000		45,000
DOT-OS-60148	PURDUE UNIVERSITY J. Drake "Feasibility of and Design of Cost Effective Computer Based Information Systems to Increase Productivity of Present and Future Urban Transportation Systems"	69,755			
DOT-OS-60149	RICE UNIVERSITY J. Margave "Flammability Studies and Toxicological Evaluation of Materials Used In Transportation Vehicles"	125,000			
DOT-OS-60150	STANFORD UNIVERSITY "Development of Research in the Construction of Transportation Facilities: A Study of Needs, Objectives, Resources, and Mechanisms for Implementation"	79,980		74,996	58,838
DOT-OS-60151	STANFORD UNIVERSITY J. Powell "Closed Loop Control of Automotive Engines"	65,759		2,000	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1976, Continued**

Contract No.	University/Principal Investigator/Title	Funding				
		1976	1977	1978	1979	1980
DOT-OS-60152	UNIVERSITY OF TEXAS, ARLINGTON R. Woods "Investigation of Air-Modulated Fluidic Fuel Injection System"	\$ 30,269	\$	\$	\$	\$
DOT-OS-60125	UNIVERSITY OF TEXAS, AUSTIN A. Healey "Transportation to Fulfill Human Needs in the Rural/Urban Environment—Automobile Ride-Quality Evaluation"	23,970				
DOT-OS-60123	TEXAS SOUTHERN UNIVERSITY N. Lede "Strengthening Organizational Capabilities and Techniques for Comprehensive Transportation Planning"	30,000				
DOT-OS-60124	UNION COLLEGE R. Mittal "Intercity Rail Energy Efficiency for Passenger and Freight Movement"	39,110				
DOT-OS-60174	UNIVERSITY OF UTAH I. Einhorn "Development of a Protocol and Combustion Exposure Chamber for Evaluating Combustion Product Toxicity and Smoke Resulting from Burning Transportation Vehicle Interior Materials"	25,000	35,000		66,0	6,595
DOT-OS-60175	VIRGINIA POLYTECHNIC INSTITUTE P. Scanlon "A Study of Lead, Cadmium, Nickel and Zinc Levels in Soil, Vegetation, Invertebrates and Mammals Associated with Highways of Different Traffic Densities"	52,316				
DOT-OS-60176	UNIVERSITY OF WEST VIRGINIA C. Balanis "Antenna System Polarization and Location for 'Microwave Landing System' "	37,661				
DOT-OS-60177	UNIVERSITY OF WISCONSIN, MADISON N. Beachley/A. Frank "Flywheel Energy Management Systems for Improving the Fuel Economy of Motor Vehicles"	100,000				
		\$1,960,869	\$238,600	\$391,838	\$213,875	\$6,595

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1977\***

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>	
		<b>1977</b>	<b>1978</b>
DOT-OS-70040	UNIVERSITY OF ARKANSAS L. Thibodeaux "Spill of Soluble, High Density, Immiscible Chemicals on Water"	\$43,845	\$54,000
DOT-OS-70041	BOSTON COLLEGE J. Anderson "Quality of Service and Regulation in Air Passenger Transport"	55,999	
DOT-OS-70042	UNIVERSITY OF CALIFORNIA, IRVINE J. Perry "The Impact of Union-Management Relations on Productivity and Efficiency in Urban Mass Transit"	63,274	
DOT-OS-80011	UNIVERSITY OF CALIFORNIA, LOS ANGELES D. Shoup "The Effect of Employer Subsidized Parking on Commuting Behavior and Transportation System Performance"		23,999
DOT-OS-70080	CARNEGIE-MELLON UNIVERSITY M. Visscher "Marine Safety and Environmental Control: An Economic Analysis"	65,911	
DOT-OS-70044	CLARK COLLEGE N. Jackson "Neighborhood Viability and Transit Development: An Ecological Model for Land-Use Forecasting in Atlanta"	47,600	2,040
DOT-OS-70045	CORNELL UNIVERSITY F. Moon "Infrared Techniques in Magnetic Levitation and Propulsion Guideway Design"	65,000	50,000
DOT-OS-80006	DARTMOUTH COLLEGE T. Adler "Techniques for Analyzing the Productivity and Efficiency of Rural Transit Systems"		46,381
DOT-OS-80005	HOWARD UNIVERSITY J. Savage, Jr. "Survey of Black Single-Parents Family Transportation Needs"		83,000

\*Including Transition Quarter FY 1977.

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1977, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1977</b>	<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-OS-70048	UNIVERSITY OF ILLINOIS, CHICAGO CIRCLE R. Michaels “Conference for Applying Behavioral Science to Transportation Policy, Planning and Programming”	\$47,949	\$	\$	\$
DOT-OS-80020	UNIVERSITY OF ILLINOIS, URBANA R. Chien “Artificial Intelligence and Human Error Prevention—A Computer Aided Decision-Making Approach”		85,000		
DOT-OS-80021	UNIVERSITY OF ILLINOIS, URBANA J. Liebman “Decision Models for Transportation Network Capacity Expansion”			39,990	
DOT-OS-70050	UNIVERSITY OF MAINE P. Camp “Electrical Properties of Ice-Solid Interfaces”	29,679			
DOT-OS-70051	UNIVERSITY OF MARYLAND K. Finsterbusch “The Development and Testing of Indicators of Neighborhood Cohesion and Other Social Characteristics for Assessing and Predicting Transportation Impacts on Neighborhoods”		53,000		
DOT-OS-70052	MASSACHUSETTS INSTITUTE OF TECHNOLOGY J. Hedrick “Performance Limits of Rail Passenger Vehicles: Evaluation and Optimization”	70,000	68,800	26,354	73,000
DOT-OS-70053	MASSACHUSETTS INSTITUTE OF TECHNOLOGY M. Manheim “Utilization of Vehicle, Labor and Fixed Facility Resources in Multi-Modal Transportation Systems”	58,000			
DOT-OS-70054	MASSACHUSETTS INSTITUTE OF TECHNOLOGY M. Ben-Akiva “Understanding, Prediction and Evaluation of Transportation Related Consumer Behavior”	69,000	70,000		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1977, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1977</b>	<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-OS-70055	MASSACHUSETTS INSTITUTE OF TECHNOLOGY R. Simpson "Operator Workload Measurement"	\$62,849	\$30,000	\$	\$
DOT-OS-70056	UNIVERSITY OF MICHIGAN H. Fogler "Physical Properties of Fuel/Water Emulsions"	65,000	60,000	4,200	
DOT-OS-70057	NEW YORK, POLYTECHNIC INSTITUTE OF P. Habib "Improving Pedestrian Crosswalk Safety on One-Way Street Networks"	30,028			
DOT-OS-70084	NEW YORK, POLYTECHNIC INSTITUTE OF J. Falcocchio "Mobility of the Handicapped and Elderly"	30,000			
DOT-OS-70058	NEW YORK, STATE UNIVERSITY OF, Buffalo E. Selig "A Theory for Track Maintenance Life Prediction"	80,000	75,000		1,752
DOT-OS-80007	NORTH CAROLINA A&T STATE UNIVERSITY A. Kidder "An Analysis of Shipper/Receiver Transportation Mode Choice in Selected Rural Communities"	60,085	32,030		
DOT-OS-80018	NORTHWESTERN UNIVERSITY M. Turnquist/R. Neuschel "Control of Service Reliability in Bus Transit Networks"	41,222	44,750		
DOT-OS-70061	NORTHWESTERN UNIVERSITY R. Basemann/A. Daughety "Development of Hybrid Cost Functions from Engineering and Statistical Techniques: The Case of Rail"	57,999	66,000		
DOT-OS-70062	NORTHWESTERN UNIVERSITY F. Koppleman "Consumer Oriented Transportation Service: Modification and Evaluation"	65,000			

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1977, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1977</b>	<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-OS-70063	OLD DOMINION UNIVERSITY R. Richman "Transportation Impacts and Coastal Zone Management"	\$45,325	\$	\$	\$
DOT-OS-70064	UNIVERSITY OF PENNSYLVANIA W. Allen "An Examination of the Unregulated Trucking Experiences in New Jersey"	34,999			
DOT-OS-70065	UNIVERSITY OF PENNSYLVANIA P. Shaman "Optimal Control of Air Traffic"	56,835	59,998		
DOT-OS-70066	PENNSYLVANIA STATE UNIVERSITY J. Nelson "Aircraft Noise Abatement Benefits—Theory and Measurement"	42,998			
DOT-OS-70067	PRINCETON UNIVERSITY E. Durbin "Evaluation of Achievable Internal Combustion Engine Economy and Emissions Performance by Improved Engine Control"	75,705	89,000	90,000	
DOT-OS-80008	PRINCETON UNIVERSITY J. Lutin "Alternative Policies for Implementing Transit Corridor Land-Use Management and Development"		25,956		
DOT-OS-70069	PURDUE UNIVERSITY M. Putsay "The Impact of Federal Trucking Regulation on Service to Small Communities"	40,000			
DOT-OS-70070	RENSSELAER POLYTECHNIC INSTITUTE E. Altwicker "Relationship Between Specific Non-Methane Hydrocarbons and Ozone in Ambient Air and Their Role in Transportation Control Strategies"		72,000		
DOT-OS-70071	UNIVERSITY OF SOUTH DAKOTA J. Berkhout "The Psychophysics of Visual Acuity as a Function of Dynamic Figure/Background Relationships"	37,059			

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1977, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>			
		<b>1977</b>	<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-OS-70072	SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY T. Ashworth “Investigation of the Basic Forces Involved in the Adhesion of Ice to Highway Surface”	\$ 59,513	\$ 60,000	\$ 50,000	\$
DOT-OS-70003	STANFORD UNIVERSITY R. Shevell “Advanced Urban Transportation System Analysis Methodology”	44,990			
DOT-OS-70073	UNIVERSITY OF TENNESSEE F. Davis, Jr. “Developing Alternatives to Resolve the Evolving Insurance Dilemma for Operators of High Occupancy Vehicles”	62,000		54,000	
DOT-OS-70074	UNIVERSITY OF TEXAS, AUSTIN D. Klingman “Improving Flow Management and Control Via Shortest Path Analysis”	67,524	60,000	—	98,046
DOT-OS-70075	UNIVERSITY OF TEXAS, AUSTIN A. Healey “Ride Quality Studies in Rubber-Tired Automated Guideway Transit Systems”	50,000	53,298		
DOT-OS-80013	VIRGINIA POLYTECHNIC INSTITUTE & C. Desai “Interaction and Load Transfer Through Track-Guideway Systems”	70,000	65,655	79,855	
		<b>\$1,749,081</b>	<b>\$1,257,769</b>	<b>\$432,989</b>	<b>\$252,653</b>

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1978**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-RC-82001	BISHOP COLLEGE C. Hunter "The Relationship of Established Transportation Routes to the Delivery of Health Care Services for the Elderly and Poor"	\$55,148	\$	\$
DOT-RC-82015	BOWLING GREEN STATE UNIVERSITY M. Pustay "Utilization of ICC Operating Rights to Evaluate the Impact of ICC Regulation"	52,622		4,766
DOT-RC-82002	UNIVERSITY OF CALIFORNIA, IRVINE J. Perry "The Impact of Labor-Management Relations on Productivity and Efficiency in Urban Mass Transit"	49,986		
DOT-RC-82003	DARTMOUTH COLLEGE T. Adler "Interactions between National Energy Supply and Transportation-Related Energy Consumption"	56,200		
DOT-RC-82004	GEORGIA STATE UNIVERSITY J. Lemly "An Evaluation of Potential Ability of Geographic Based Shippers Cooperative Associations to Provide Benefits to Shippers in Low Traffic Density Areas of the United States"	31,741	20,900	11,500
DOT-RC-82029	UNIVERSITY OF IOWA I. Levin "The Developments and Test of Mathematical Models of Traveler Perceptions and Decisions"	61,700		
DOT-RC-82005	JOHN HOPKINS UNIVERSITY R. Weissbrod "An Analysis of Transportation/Land Use Interactions"	60,000		
DOT-RC-82006	JOHN HOPKINS UNIVERSITY R. Green "Comparison Between X-Ray Diffraction and Ultrasonic Non-Destructive Evaluations of Residual Stress in Structural Materials"	55,790		
DOT-RC-82007	LEHIGH UNIVERSITY F. Erdogan "Fracture Analysis of Pipelines"	50,300	99,339	
DOT-RC-82028	UNIVERSITY OF MASSACHUSETTS J. Collura "Assessing Local Deficit and Social Service Agency User Charges for Rural Public Transportation"	55,741	51,980	8,175

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1978, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>	
		<b>1978</b>	<b>1979</b>
DOT-RC-82008	UNIVERSITY OF MINNESOTA P. Michalopoulos "Development and Evaluation of Optimal Control Strategies for Large Scale Urban Transportation Networks"	\$60,000	\$67,000
DOT-RC-82009	UNIVERSITY OF MISSOURI, ROLLA J. Podzimek "The Measurement and Identification of Ultrafine Aerosols in Polluted Air"	51,688	
DOT-RC-82010	UNIVERSITY OF NOTRE DAME R. Nelson "A Combined Experimental and Analytical Investigation of the Influence of Low Level Wind Shear on the Handling Characteristics of Aircraft"	30,275	35,282
DOT-RC-82011	UNIVERSITY OF OKLAHOMA S. Gollahalli "Combustion of Fuel-Water Emulsions in Diesel Engines"	43,388	
DOT-RC-82012	UNIVERSITY OF OKLAHOMA W. Allen "An Examination of the Unregulated Trucking Experience in Delaware"	23,733	
DOT-RC-82013	UNIVERSITY OF PENNSYLVANIA W. Allen "A Case Study of the 1977 Expansion of the Philadelphia Commercial Zone"	30,977	
DOT-RC-82030	PENNSYLVANIA STATE UNIVERSITY D. Anderson "Fingerprinting Versus Field Performance of Paving Grade Asphalts"	50,490	56,943
DOT-RC-82014	PRINCETON UNIVERSITY J. Lutin "Developing a Coordinated Transportation Planning Process for Coastal Zone Management"	53,984	
DOT-RC-82026	PRINCETON UNIVERSITY R. Caudill "Longitudinal Control to Improve Performance, Reliability, and Safety in Automated Vehicle Systems"	55,421	
DOT-RC-82016	RENSSELAER POLYTECHNIC INSTITUTE P. Michandani "Development of a Normative Method to Plan Urban Structure Considering Spatial and Temporal Interaction Among Transportation, Population and Employment/Public Facilities"	59,900	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1978, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1978</b>	<b>1979</b>	<b>1980</b>
DOT-RC-82017	SHAW UNIVERSITY E. Jones "Using School Buses to Transport Elderly and Handicapped Non-Wheelchair Users: A National Feasibility Study"	\$ 57,000	\$	\$
DOT-RC-82027	TEXAS SOUTHERN UNIVERSITY N. Lede "A Pilot Study to Evaluate Citizen Participation Models for Policy Planning"		63,378	
DOT-RC-82018	UTAH STATE UNIVERSITY W. Phillips "A New Continuum for Traffic Flow"		52,732	57,491
DOT-RC-82019	UNIVERSITY OF VIRGINIA W. Pilkey "Limiting Performance Approach to Systems Design."		61,000	100,000
DOT-RC-82020	VIRGINIA STATE COLLEGE J. Campbell "Socio-Economic Impact on Intra-State Motor Carrier Regulations on Rural Development in South Central Virginia"		71,000	59,377
DOT-RC-82021	UNIVERSITY OF WASHINGTON J. Schneider "Increasing Network Flow Simulation Model Performance Through Graphic and Heuristic User Aids"		53,300	
DOT-RC-82022	WASHINGTON STATE UNIVERSITY D. Breen "Common Carrier Obligations and the Provision of Motor Carrier Service to Small Rural Communities"		64,300	
DOT-RC-82031	WEST VIRGINIA UNIVERSITY T. Campbell "The Influence of Coal Transport Costs on the Optimal Distribution of Coal and the Optimal Location of Electric Power Generating Plants"		46,765	55,981
DOT-RC-82023	UNIVERSITY OF WISCONSIN, Milwaukee D. Gensch "Predicting Public Response to Prospective Transportation Policies Based on Their Stated Intention"		75,000	
			\$1,533,559	\$444,916
				\$183,818

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1979**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1979</b>	<b>1980</b>	<b>1981</b>
DOT-RC-92010	UNIVERSITY OF CALIFORNIA, IRVINE W. Recker "Economic Structure, Community Development, and Transportation Systems: An Empirical Analysis of Household Activity Patterns"	\$ 64,500	\$	\$
DOT-RC-92011	CENTRAL STATE UNIVERSITY L.S. Smith "Microencapsulation for Transportation Safety"	108,724		
DOT-RC-92012	IOWA STATE UNIVERSITY R. Handy "Geophysical Grouting Control System"	71,903		46,528
DOT-RC-92013	KANSAS CITY UNIVERSITY E. R. Russell "A Community Model for Handling Hazardous Materials Transportation Emergencies"	156,488		7,635
DOT-RC-92014	UNIVERSITY OF LOWELL S. Serabian "Reliability of Ultrasonic Weld Interrogation Methods"	63,309		55,519
DOT-RC-92015	UNIVERSITY OF LOWELL N. Gartner "Demand-Responsive Decentralized Urban Traffic Control"	67,120		59,918
DOT-RC-92016	MASSACHUSETTS INSTITUTE OF TECHNOLOGY F. Moavenzadeh "Development of Quality Standards and Impact Models for Highway Maintenance"	73,300		
DOT-RC-92017	MASSACHUSETTS INSTITUTE OF TECHNOLOGY P. Houpt "Modeling and Dynamic Control of Spark-Ignited Internal Combustion Engines"	287,100		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1979, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1979</b>	<b>1980</b>	<b>1981</b>
DOT-RC-92018	UNIVERSITY OF MINNESOTA K.S. Kumar "Reliable Decentralized Control Strategies for Freeway Regulation"	\$ 50,000	\$	\$
DOT-RC-92019	UNIVERSITY OF MINNESOTA Y. Stephanedes "Analyzing the Impacts of Transportation Policies on Rural Mobility and Economic Development"	65,000		58,800
DOT-RC-92020	UNIVERSITY OF NEBRASKA, LINCOLN P. McCoy "Citizens' Perceptions of Highway Impacts"	69,470		
DOT-RC-92021	UNIVERSITY OF NEBRASKA, LINCOLN E. Post "Cost-Effectiveness of Retrofitting Concrete Median Barriers"	76,455		
DOT-RC-92022	NEW YORK, POLYTECHNIC INSTITUTE OF E. Levi "Development of Improved Analytical Techniques for the Design of Three-Phase Traction Motors"	125,727		
DOT-RC-92023	NEW YORK, POLYTECHNIC INSTITUTE OF R. Drenick "Decentralized Control of Street Traffic"	44,500	65,345	
DOT-RC-92024	NEW YORK, STATE UNIVERSITY OF, BINGHAMTON C. Kern "Impact of Transportation Policy on the Spatial Distribution of Retail Activity"	94,000		96,513
DOT-RC-92025	UNIVERSITY OF NORTH CAROLINA G. Gilbert "Economics of Scale in the U.S. Intercity Bus Industry"	33,782		
DOT-RC-92026	NORTH CAROLINA A&T STATE UNIVERSITY L. Sen "Empirical Test of the Utility of Attitudinal Measures for Short Term Public Transportation Planning"	71,000		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1979, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>		
		<b>1979</b>	<b>1980</b>	<b>1981</b>
DOT-RC-92027	NORTH CAROLINA CENTRAL UNIVERSITY W.W. Nichols, Jr. "The Equity and Adequacy of Transportation Facilities in Black Communities: The Problem of Residence-Shopping Place Separation"	\$50,000	\$	\$
DOT-RC-92028	NORTHWESTERN UNIVERSITY A. Anas "Effects of Transportation on the Tax Base and Development of Cities"	77,205	77,250	
DOT-RC-92029	UNIVERSITY OF OKLAHOMA L. Canter "Environmental Protection During and Following Transportation Accidents/Emergencies"	69,889		
DOT-RC-92030	UNIVERSITY OF PENNSYLVANIA E. Morlok "Development, Testing and Applications of Transportation Supply Models"	68,988		
DOT-RC-92031	UNIVERSITY OF PITTSBURGH B. Bhargava "Software Reliability in Air Traffic Control Systems"	47,000		
DOT-RC-92032	PRINCETON UNIVERSITY H.C. Curtiss, Jr. "Lateral Stability and Dynamic Response of Ram Air Cushion Vehicles"	73,500	79,689	
DOT-RC-92033	PRINCETON UNIVERSITY L. Sweet "Improvement in Rail Vehicle Dynamic Performance through Control of Linear Motor Lateral and Normal Forces"	82,500	82,000	
DOT-RC-92034	PURDUE UNIVERSITY E. Ting "Non-Destructive Determination of Residual Service Life of Bridge Structures"	72,806		

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1979, Continued**

<u>Contract No.</u>	<u>University/Principal Investigator/Title</u>	<u>Funding</u>		
		<u>1979</u>	<u>1980</u>	<u>1981</u>
DOT-RC-92035	SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY V. Ramakrishnan "Superplasticized Concretes for Rehabilitation of Bridge Decks and Highway Pavements"	\$ 119,900	\$	\$
DOT-RC-92036	UNIVERSITY OF SOUTHERN CALIFORNIA H. Roland "Study of the Capability of Risk Analysis for the Support of the Formulation of Regulations for the Transportation of Hazardous Materials"	87,300		
DOT-RC-92037	TEXAS A&M UNIVERSITY J. Lou "A Nonlinear Analysis of Liquid Sloshing in Rigid Containers"	75,500		80,000
DOT-RC-92038	TEXAS A&M UNIVERSITY W. Roeseler "The Impact of Technological Changes in Transportation Networks on Regional Productivity and Development"	80,600		
DOT-RC-92039	UNIVERSITY OF TEXAS, AUSTIN D. Klingman "Improvement of Large Scale Network Procedures"	49,745		
DOT-RC-92040	UNIVERSITY OF TEXAS, Dallas R. Briggs "The Impact of the Interstate Highway System on Non-Metropolitan Growth"	45,400	702	
DOT-RC-92041	UNIVERSITY OF WASHINGTON J. Schneider "Development of Improved Urban Travel Pattern Mapping Tools for Analysis of Land-Use/Transportation Interrelationships"	85,100		
DOT-RC-92042	WASHINGTON STATE UNIVERSITY N. Deo "Parallel Algorithms for Large Scale Network Problems"	34,975	37,429	
DOT-RC-92043	WEST VIRGINIA UNIVERSITY E. Nuemann "Synthetic Travel Forecasting using Traffic County Correlations"	55,000		
DOT-RC-92044	UNIVERSITY OF WISCONSIN, MILWAUKEE E. Beimborn "Development of Procedures for Improved Utilization of Research Results in Urban Transportation"	51,942		
		\$2,750,628	\$103,476	\$636,214

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1980**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>	
		<b>1980</b>	<b>1981</b>
DT-RS-56-80C-00006	BOWLING GREEN STATE UNIVERSITY M. Pustay "Intrastate Motor Carriage and Federal Policy Towards Small Community Service"	\$ 63,500	\$
DT-RS-56-80C-00007	BROWN UNIVERSITY S. Dafermos "Multimodal Traffic Equilibrium Network Models and Algorithms"	48,000	
DT-RS-56-80C-00008	BROWN UNIVERSITY B. Zimmer "Community Development and Changing Travel Patterns"	52,291	
DT-RS-56-80C-00009	UNIVERSITY OF CALIFORNIA, LOS ANGELES K. Ono "Nondestructive Evaluation of Longitudinal Rail Force by Acoustic Emission Method"	110,000	
DT-RS-56-80C-00010	CALIFORNIA INSTITUTE OF TECHNOLOGY C.D. Babcock "Damage Assessment and Confinement in Offshore Pipelines"	77,342	
DT-RS-56-80C-00011	CLARK COLLEGE L. L. Earvin "Assessing the Potential for Individual Energy Savings through Coordinated Transit Planning and the Neighborhood District Development"	48,000	
DT-RS-56-80C-00012	CORNELL UNIVERSITY M. Turnquist "Short-Range Operations Planning Models for Transit Systems"	41,209	
DT-RS-56-80C-00013	CORNELL UNIVERSITY M. Turnquist "Management of Railroad Car Distribution"	53,774	
DT-RS-56-80C-00014	DARTMOUTH COLLEGE G. Kocur "A Unified Approach to Performance Standards and Fare Policies for Urban Transit Systems"	65,600	
DT-RS-56-80C-00015	GEORGIA INSTITUTE OF TECHNOLOGY S. Ramalingam "Fundamental Studies in Tribology as Related to Automotive Fuel Economy"	145,000	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1980, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>	
		<b>1980</b>	<b>1981</b>
DT-RS-56-80C-00016	UNIVERSITY OF KENTUCKY A.F. Seybert "Tire/Roadway Interaction and Its Effects on Vehicle Safety Trade-offs"	\$ 66,000	\$ 1,800
DT-RS-56-80C-00017	MASSACHUSETTS INSTITUTE OF TECHNOLOGY Y. Sheffi "Efficient Data Collection Schemes for Disaggregate Travel Demand Models Estimation"	75,000	
DT-RS-56-80C-00018	MASSACHUSETTS INSTITUTE OF TECHNOLOGY J.K. Hedrick "Application of Active and Passive Suspension Techniques to Improve High Speed Ground Vehicle Performance"	90,000	90,000
DT-RS-56-80C-00019	MASSACHUSETTS INSTITUTE OF TECHNOLOGY J. Sussman "Strategies for Improving Rail Car Distribution: A Study of Overcoming Organizational and Institutional Barriers to Innovation"	107,000	
DT-RS-56-80C-00020	UNIVERSITY OF MICHIGAN, ANN ARBOR D.E. Cleveland "Advanced Transportation Accident Causal Models"	94,020	
DT-RS-56-80C-00021	UNIVERSITY OF MICHIGAN, DEARBORN K.S. Varde "A Study of Diesel Spray Characteristics at High Injection Pressures"	52,000	2,125
DT-RS-56-80C-00022	NEW YORK, POLYTECHNIC INSTITUTE OF W.H. Crowell "An Assessment of the Interstate Highway Trade-in Process"	44,992	
DT-RS-56-80C-00023	UNIVERSITY OF NORTH FLORIDA & EDWARD WATERS COLLEGE J. Smith, Jr. "Minority Participation in the Regulated Motor Carrier Industry"	111,000	
DT-RS-56-80C-00024	NORTHWESTERN UNIVERSITY F.S. Koppelman "Identification of Conditions for Effective Transferability of Disaggregate Choice Models"	68,345	
DT-RS-56-80C-00025	UNIVERSITY OF PENNSYLVANIA W. Bruce Allen "The Augmentation of Freight Transportation Data Sets"	43,486	

**PROGRAM OF UNIVERSITY RESEARCH: CONTRACT INFORMATION**  
**FY 1973—FY 1980**  
**Contracts Initiated FY 1980, Continued**

<b>Contract No.</b>	<b>University/Principal Investigator/Title</b>	<b>Funding</b>	
		<b>1980</b>	<b>1981</b>
DT-RS-56-80C-00026	UNIVERSITY OF PITTSBURGH B. Bhargava "System Structure for Software Reliability in Enroute ATC System"	56,000	\$
DT-RS-56-80C-00027	UNIVERSITY OF PUERTO RICO, MAYAGUEZ R. Pacheco "Highway Conditions and Highway Accidents: A Multivariate Design Model"	206,197	
DT-RS-56-80C-00028	RENSSELAER POLYTECHNIC INSTITUTE A. Eiger "The Development of UTCS/NETSIM/ICG: An Integrated Urban Traffic Control System; Network Simulation Interactive Computer Graphics Program"	80,000	
DT-RS-56-80C-00029	RUTGERS UNIVERSITY K.T. Rhee "A Study of Particulate Formation and Radiant Heat Loss in Direct Injection-type Diesel Engines"	61,249	
DT-RS-56-80C-00030	STANFORD UNIVERSITY J.D. Powell "Air-Fuel Mixture Sensing and Control in Automotive Engines"	84,995	
DT-RS-56-80C-00031	STANFORD UNIVERSITY O.D. Sherby "Development of Ultrahigh Carbon (UHC) Steels of Automotive Applications"	108,000	
DT-RS-56-80C-00032	TEXAS A&M UNIVERSITY D.E. Bray "Optimization Study for Ultrasonic Flaw Detection in Railroad Rail"	50,364	
DT-RS-56-80C-00033	UNIVERSITY OF VIRGINIA R.M. Inigo "Application of Image Processing to Vehicle Guidance and Safety"	85,500	
DT-RS-56-80C-00034	UNIVERSITY OF WASHINGTON J. Schneider "Development of Urban Form Measures to Aid Post—1980 Investigations of Land Use—Transportation—Energy Interrelationships"	54,597	35,915
DT-RS-56-80C-00035	WORCESTER POLYTECHNIC INSTITUTE J.D. Sage "Shear Strength Characteristics of Soils Subjected to Frost Action"	78,910	
		167	\$2,322,871
			\$129,840

**SUMMARY**  
**FY 1973—FY 1980**  
**PROGRAM OF UNIVERSITY RESEARCH**  
**FUNDING FOR UNIVERSITY RESEARCH AND SEMINAR CONTRACTS**

<b><u>FY1973</u></b>	<b><u>FY1974</u></b>	<b><u>FY1975</u></b>	<b><u>FY1976</u></b>
\$2,286,961	\$3,617,020	\$5,213,225	\$3,980,147
<b><u>FY1977</u></b>	<b><u>FY1978</u></b>	<b><u>FY1979</u></b>	<b><u>FY1980</u></b>
\$2,452,543	\$3,577,971	\$3,912,408	\$2,876,795
<b><u>FY1981</u></b>			
\$ 766,054			

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